FORESTRY RESEARCH HIGHLIGHTS

1967

Annual Report

Rocky Mountain Forest and Range Experiment Station

Forest Service
Raymond Price, Director

U.S. Department of Agriculture
Fort Collins, Colorado

PROJECT LOCATIONS

Albuquerque, New Mexico
New Federal Building

Bottineau, North Dakota
Shelterbelt Laboratory

Flagstaff, Arizona
Forestry Sciences Laboratory
Northern Arizona University

Fort Collins, Colorado
240 West Prospect
Colorado State University

Laramie, Wyoming
Forest Range and Watershed Laboratory
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
Forestry Sciences Laboratory
South Dakota School of Mines
and Technology

Tempe, Arizona
Forest Hydrology Laboratory
Arizona State University

Tucson, Arizona
Tumamoc Hill
University of Arizona

Station headquarters is at Fort Collins, Colorado,
in cooperation with Colorado State University

ABOUT THE COVER:

The new headquarters office-laboratory on the Colorado State University campus (240 West Prospect), Fort Collins, Colorado, was dedicated July 28, 1967.

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

FORESTRY RESEARCH HIGHLIGHTS 1967

ANNUAL REPORT

Mention of a trade product does not constitute endorsement

March 1968

Contents

A brief summary

Range Management and Wildlife Habitat Research was adjusted to begin research on management of elk ranges in Wyoming. We are studying patterns of use and plant species grazed in each season on the major habitat types to provide the background for coordinating elk habitat improvement and use with other uses of the land. Emphasis is also being placed on nutritional values of native plants—palatability, chemical constituents, digestibility—for both livestock and wildlife. Other research continues to explore the fundamentals of plant and animal ecology in relation to land treatments, range production, and quality of wildlife habitat.

A study in the Big Horn Mountains, Wyoming, showed that it may not be necessary to defer cattle grazing after chemical control of big sagebrush where there are good grass stands under sagebrush and growing conditions are favorable. In high mountain grasslands of Colorado, many forbs are utilized well by cattle and provide nutritious forage. Hence, emphasis is being given to the place and value of forbs in the annual forage crop. Nine years of pocket gopher exclusion from mountain grassland range resulted in relatively little change in total herbage production. However, there were increases in perennial forbs, formerly taken by gophers. We are finding that chaparral ranges converted to grass have a high initial grazing capacity. Also, on semidesert grassland ranges, spring and spring-summer deferments were found to be more effective for range improvement than either winter deferment or summer deferment alone.

Current findings in wildlife habitat and **Forest Biology Research** indicate that methods of handling tree overstories are important to game use of the habitat. Also, in sagebrush winter range, snow cover is an important factor influencing forage availability to deer. In the Black Hills a number of good shrubs from other lands have been found to be adapted, and are being tested in pilot plantings for improving deer winter range. Wild turkeys in the Southwest were found to use openings more than other habitat types, but usually went less than 50 yards from cover. Mixed pine, oak, and juniper forests were next in importance.

In **Watershed Management Research,** special emphasis is being placed on some of the basic processes that operate in a watershed. How timber harvesting patterns influence wind movement over and across the watershed, and how these in turn influence snow accumulation and melt, peak streamflows, and sediment behavior are some of the watershed functions under study.

Some additional studies are underway on: (1) the effects of spraying sagebrush and chaparral on soil moisture and erosion; (2) the part soil micronutrients play in vegetation establishment; (3) how size, scarification, and age of seeds affect germination of alkali sacaton; (4) the potential danger to water supplies from chemical brush treatment; and (5) the effect burning has on chaparral and sediment movement.

Special studies on avalanche forecasting and factors needed for predicting avalanche occurrence are being studied at major ski areas. Basic studies on the movement of snow by wind and how snow crystallization affects avalanche conditions will provide a better understanding of the physical and mechanical properties of snow and of mountain weather patterns.

Research on transpiration, the use of fluorescent dyes for measuring streamflow, the effect of timber harvesting practices, and treatment of

chaparral by burning and chemical methods as they affect streamflow are being continued.

Forest Economics Research continued to be focused on evaluating land management practices designed to increase streamflow in the Southwest. Six of the 18 small experimental watersheds in the Beaver Creek Pilot Watersheds are now under treatment. These tests include removal of juniper by cabling, sawing, and burning; clearcutting and strip cutting of ponderosa pine; and reduction of grasses and other herbage by grazing.

Beaver Creek scientists have developed a system of measuring sediments in streamflow. They also are working on ways of predicting sediment yields from measurable watershed features.

Work so far indicates that winter snowstorms are the most important source of moisture on Arizona's pine watersheds. Patterns of forest thinning and strip cutting are being investigated as ways of increasing water yields from snow.

Forest Products Marketing Research was aimed at finding new or improved marketing opportunities for products of the forests of the Central and Southern Rocky Mountain areas.

A study showed that, although the number of Arizona lumber mills declined from 66 to 25 between 1956 and 1965, the State's annual output of lumber grew from 241 million to 365 million board feet. Most of Arizona's lumber is marketed in the Southwest. In 1965 one-fourth of it stayed in the State and half of what was shipped out went to markets in Texas, New Mexico, Oklahoma, and California. Major problems include a relatively low-quality timber that yields lower grades of logs and lumber. Market values for lower grades of lumber are declining.

The national plywood market has been studied and described as a first step in analyzing potential markets for plywood that may be produced in the Central Rockies or the Southwest. In 1965, 12,446 million square feet of softwood plywood was produced, most of it on the West Coast.

Research in Forest Products Utilization is seeking new or improved products that will make possible more efficient and profitable use of the timber resources of the Central Rockies and the Southwest.

A decking for roofs and floors has been developed to make better use of the abundant lower common grades of lumber. The lumber is "sandwiched" or laminated and glued to create a strong panel.

A preliminary test indicates that veneer yields from Black Hills ponderosa pine may be adequate for use in sheathing-grade plywood.

A special roll-laminating machine has been acquired for pilot-plant tests of overlaying lower grades of lumber with papers and vinyls to increase their usefulness and marketability.

As part of a nationwide study, utilization scientists are checking the moisture content of laminated beams in buildings so that manufacturers can fabricate beams at the proper moisture content for the area where they are to be used. At the end of the first year, most of the beams in 25 buildings in South Dakota, Colorado, New Mexico, and Arizona showed moisture contents of 6 to 8 percent.

There is new interest in the potential of the ponderosa pine forests of the Southwest for alternative products including veneer, studs, pulpwood, and poles, as well as lumber. Careful analysis of all the material harvested from an experimental clearcut area gives us an indication of the potential of cutover ponderosa pine stands. Logging-cost studies underway will yield information useful to managers and timber sale appraisers. Harvesting costs per thousand board feet of logs are heavily influenced by size of log and by total volume cut per acre.

Timber Management Research continued studies in (1) regeneration of spruce-fir, mixed conifers, and southwestern ponderosa pine, (2) management procedures and tree improvement in Black Hills ponderosa pine, and (3) establishment and management of shelterbelts for the Great Plains.

Site indexes for Engelmann spruce and physiographic site equations for aspen were completed. Severity of windthrow of spruce and lodgepole pine along the margins of clearcut strips was shown to be related to topographic factors that determine exposure to stormwinds.

The hypothesis that modifying light by summer shade improves winter survival of planted spruce seedlings was strengthened. Studies showed that water stress did not differ between shaded and unshaded seedlings. A modest water stress will stop photosynthesis, however. Survival of planted ponderosa pines was impaired by sowing grass seed at time of

planting. Pocket gophers killed many more planted pine seedlings in an area that was not grazed by cattle than in an area that was grazed heavily.

In North Dakota, narrow strips of sudangrass, planted on each side of a row of ponderosa pines, sheltered the pines from drying winds, accumulated moisture as snow, and improved survival at all seasons.

Forest Fire Research was expanded by location of the national fire-danger measurement project at Fort Collins. The project will complete the National Fire-Danger Rating System using data from all available sources.

Research on use of fire in chaparral was accelerated by completion of an experimental burning area near Prescott, Arizona, and start of a program of burning tests. Highly polished metal panels placed around small test fires reflect heat back into the fire to simulate large fires. Flames of burning chaparral reach temperatures above 1,700°F. Flammability of chaparral may be influenced by large, seasonal changes in concentration of phosphorus and potassium in the plants. Under some conditions, these chemicals inhibit combustion.

Forest Insect Research was advanced by approval of two new projects. One project, to be headquartered at Bottineau, North Dakota, will study insects affecting shelterbelts and other protective tree plantings throughout the Great Plains. The second, to be headquartered at Albuquerque, New Mexico, will study nematode parasites and predators of bark beetles nationally.

The life history of the southwestern pine tip moth was clarified in Arizona. A dimethoate treatment provided considerable protection against it.

Trends of outbreaks of the western budworm were closely related to the amount of natural mortality between the egg and one-fourth-grown larval stages. Group killing of ponderosa pines by the Black Hills beetle starts from the attack of one tree early in the flight period. This sets up an attraction for other beetles and a succession of attacks on surrounding trees. Several new species of nematode parasites of bark beetles were discovered. Two species greatly influenced the reproduction of their host. Studies of natural control of bark beetles by insect parasites and predators are continuing.

Forest Disease Research is working with the Department of Botany and Plant Pathology, Colorado State University, in studies of suspected air pollution injury to ponderosa pine, and is also assisting in Forest Service studies of the effect of mistletoe losses on yield predictions in lodgepole pine. A previously undescribed species of Ceratocystis was isolated from aspen cankers and described as C. populina. A defect study in the Black Hills confirmed early impressions of the significance of red rot in ponderosa pine, but revealed that brown rots are nearly as damaging in overmature sawtimber.

Myceliophagus nematodes were demonstrated to have a limiting effect on the development of mycorrhizae-forming fungi in New Mexico. Oak wilt is spreading in Nebraska. Bordeaux mixture can be used to control Cercospora blight of junipers and Diplodia blight of pines.

Details of these and other findings are presented in the following pages. Complete accounts of our research are released through various publications. An annotated list of publications issued in 1967 is included in the bibliography at the end of this report.

Raymond Price, Director

Figure R-1.--One of four areas used in study of the influence of deferring grazing after spraying to control big sagebrush. The area in the foreground was not deferred. Prior to control, big sagebrush cover was 15.5 percent, and density was 18 plants per 100 square feet.

Range Management and Wildlife Habitat Research

Range Management

Range recovery following sagebrush spraying not influenced by grazing deferment

The deferment of cattle grazing following chemical control of big sagebrush[1] did not increase the production of forage at four locations on the Big Horn Mountains, Wyoming. Applications of 2,4-D in 1960 and 1961 reduced the density and canopy coverage of big sagebrush by about 98 percent. In the 6 subsequent years, similar amounts and kinds of forage were produced on areas where grazing was deferred for 0, 1, 2, and 3 years (figs. R-1, R-2). Enough forage species were present under the sagebrush in these favorable growing sites to quickly revegetate the area after sagebrush control, and continued moderate grazing did not retard the process of revegetation. Reinvasion of sagebrush was negligible under all treatments.

[1] *Common and scientific names of animals and plants mentioned are listed inside the back cover. Those for diseases and insects are included in text since many are identified only by their scientific names.*

Figure R-1.

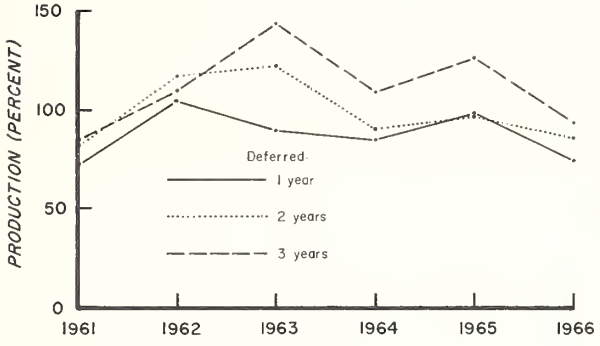


Figure R-2.--Production of Idaho fescue (as percent of that on undeferred areas) as affected by period of deferment from moderate grazing following chemical control of big sagebrush on the Buck Creek Experimental Area.

Forbs are nutritious forage on mountain grassland range

Crude protein values for the most important forbs at Black Mesa Experimental Range in western Colorado (fig. R-3) were high when compared with values for Idaho fescue at all stages of growth. Even at maturity, the forbs—aspen fleabane, aspen peavine, and agoseris—contained more protein than the minimum required for maintaining normal growth of 600-pound steers. At maturity, Idaho fescue and most other grasses are deficient in crude protein.

Phosphorus content of these forbs was also high. Phosphorus is important in both the reproduction and general health of livestock. In all comparisons the forbs contained more phosphorus at various stages of maturity than did Idaho fescue. These forbs are among the more important and more palatable forbs in the mountain grassland type, and are readily taken by cattle.

Figure R-3.--Aspen fleabane, the conspicuous flower in this photo, is both palatable and nutritious for livestock.

Figure R-4.--Annual plants were conspicuous in 1966 on gopher-infested range (left), but were scarce (right) where gophers had been controlled 9 years. Slenderleaf gilia is the principal annual.

Pocket gophers reduce forb production on mountain grassland

On the Black Mesa Experimental Range in western Colorado, perennial forbs produced 167 pounds more herbage per acre on mixed grass-forb ranges from which gophers had been excluded 9 years than on comparable areas that supported about 16 gophers per acre. Most of the increased production was in important gopher foods—common dandelion, aspen peavine, lupine, and agoseris. As one might expect, annual forbs became less productive and nearly disappeared when the soil no longer was disturbed by gophers (fig. R-4).

Grass production increased 54 pounds more per acre on the eight study areas from which gophers were excluded than where gophers were present. Shrub production was influenced even less.

Compared to the 1,000 to 1,500 pounds of herbage normally produced, changes in total herbage production attributable to pocket gopher control have been relatively small. Differences in production are due to three factors: burial of plants by gopher mounds or casts, harvesting of plants by gophers, and changes in soil characteristics following gopher control.

Parry rabbitbrush can be controlled with Tordon

Tordon 22-K applied at 2 pounds per acre in 100 gallons of water killed from 82 to 99 percent of Parry rabbitbrush on Black Mesa in western Colorado. Most effective control was obtained on plots sprayed August 17, 1965, when plants had 3 to 6 inches of new growth, and were in the early stages of flowering. Fremont geranium, an abundant forb that is grazed little, was killed 100 percent in the August spraying. Grass production was 2,474 pounds per acre on the sprayed areas as compared to 1,575 pounds on the control plots. Forb production decreased from 1,043 pounds per acre on the controls to 19 pounds on the sprayed plots. Cattle used the sprayed plots much more heavily than adjoining unsprayed areas (fig. R-5).

Figure R-5.--Forage utilization in October 1965 on plots sprayed with Tordon 22-K at 2 pounds per acre. Compare with unsprayed areas on the right and in the background.

Figure R-6.--Thirty days after seeding, more fourwing saltbush seedlings had emerged from seeds planted 1/2 and 1 inches deep than from those planted 1-1/2 to 2 inches deep.

Plant fourwing saltbush seed shallow

More fourwing saltbush seedlings emerged from shallow depths of seeding. De-winged seeds were sown at ½-, 1-, 1½-, and 2-inch depths in sandy loam and clay loam soils. Thirty days after seeding, about three times as many seedlings had emerged (34 percent) from seeds planted ½ inch deep as from seed planted 2 inches deep (fig. R-6).

Seedlings also emerged more rapidly from the shallow seeding depths. For example, 7 days after seeding, emergence was 67 percent completed for seed planted ½ inch deep, compared to only 12 percent for seeds planted 1½ inches deep. Seedlings emerged about the same in the two soils.

Seeding depths of ½ to 1 inch are suggested for de-winged seeds.

Weeping lovegrass stands on converted chaparral lands decline under nonuse

Seeded stands of weeping lovegrass on ungrazed areas completely or partially cleared of chaparral in central Arizona show signs of deterioration after a few years, even without grazing. Grass cover and production reached a peak about 2 years after treatment, then began to decrease (fig. R-7). Decreases were most obvious on plots where more than 50 percent of the brush had been killed.

Crested wheatgrass withstood spring, fall, and spring-fall grazing equally well

Crested wheatgrass can be grazed efficiently any time during the growing season. Ten years of grazing during the spring, the fall, or both spring and fall did not affect forage yields at the Manitou Experimental Range in central Colorado. Grazing intensity in all cases was to a 1-inch stubble for the period of grazing; the plants grew or regrew in other periods. In

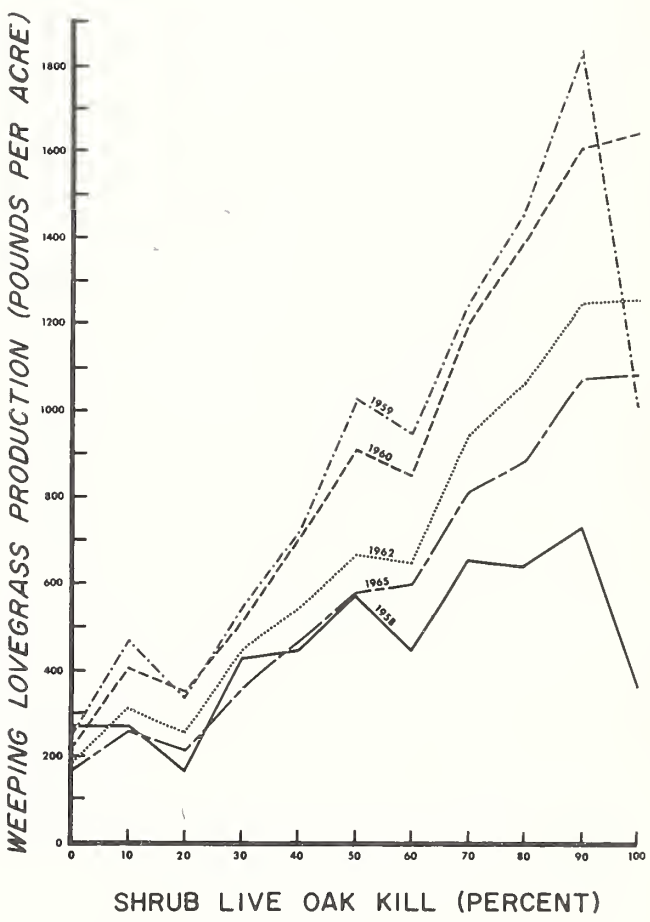


Figure R-7.--Weeping lovegrass production on plots with varying percentages of oak kill.

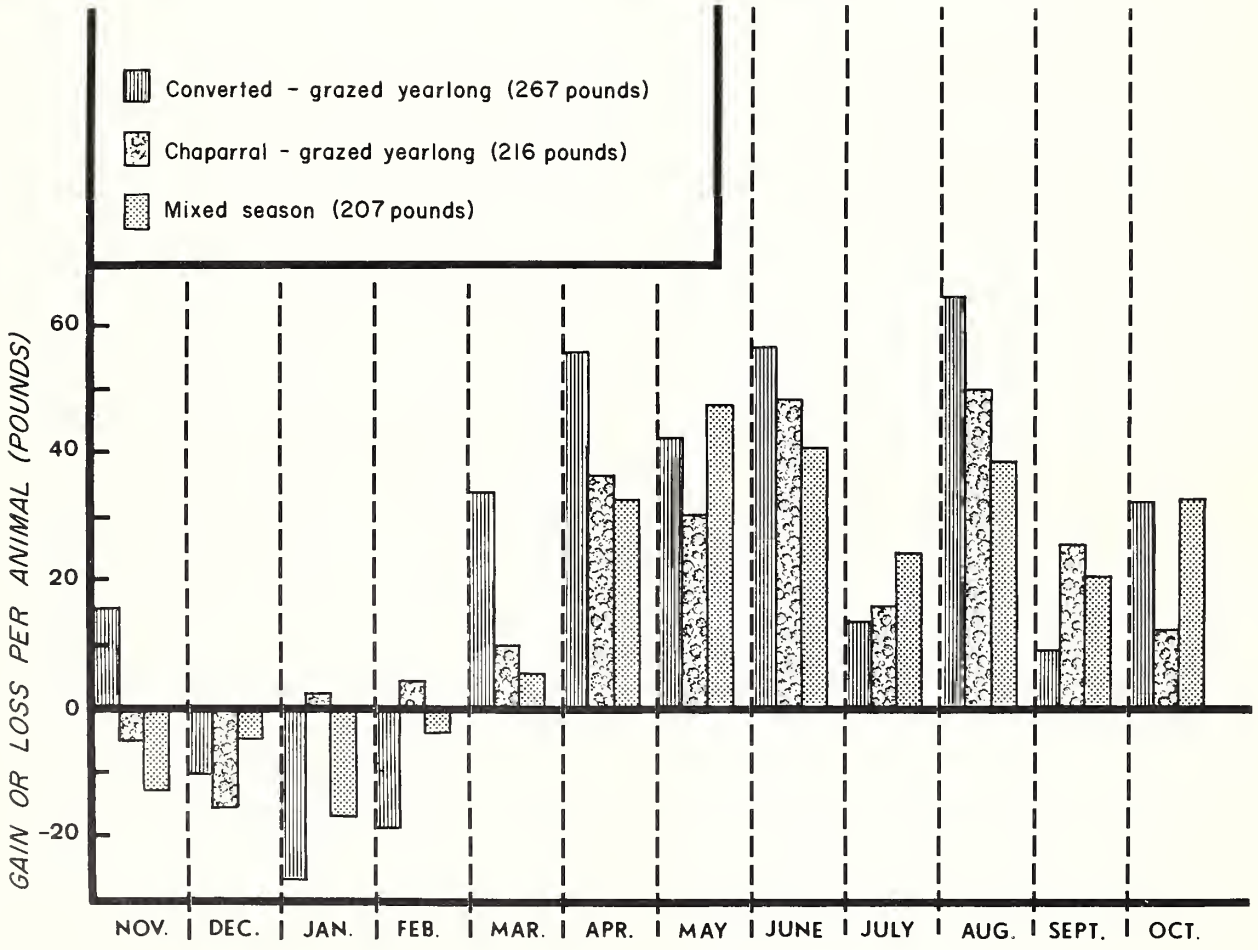
1957, ranges which were to be grazed both spring and fall produced 2,457 pounds of forage per acre compared with 1,734 pounds for ranges to be grazed only in the spring and 1,894 pounds for ranges to be grazed only in the fall. Over the 10-year period the ranges retained this same relative ranking, and in only 2 out of the 10 years did either range grazed only in the spring or fall produce more forage than those grazed both spring and fall.

Undesirable species often invade good stands of crested wheatgrass. Such plants increased the least on ranges grazed only in the fall. Invading species on ranges grazed only in the spring or both spring and fall made comparable increases, which indicated that spring grazing encouraged increased growth of plants other than crested wheatgrass. Since forage yields were unaffected by seasonal treatment, however, crested wheatgrass apparently can be grazed in the spring, fall, or both spring and fall on a sustained yield basis, but with the realization that cover of other species may increase and the increase will be more noticeable on ranges grazed in spring.

Converted chaparral puts good gains on yearling cattle

Yearling cattle in central Arizona made better gains when grazed yearlong on chaparral range that was converted to weeping and Lehmann lovegrasses than on native chaparral ranges. They also made better gains than cattle grazed in summer on converted ranges and in winter on native chaparral (fig. R-8). The yearlings in all situations gained about 9 months each year and lost or barely maintained weight during the remaining 3 months. These are the preliminary results from the first 2 years of grazing on the Tonto Springs Evaluation Area, Prescott National Forest.

Figure R-8.--Average change in cattle weights when grazed (1) on natural chaparral, (2) on chaparral area converted to weeping and Lehmann lovegrasses, and (3) on each condition for part of the year--Tonto Springs Evaluation Area, Prescott National Forest.



Some grass seeds remain viable after long storage periods

Vine-mesquite, silver beardgrass, curly-mesquite, and Arizona cottontop seeds collected on the Sierra Ancha Experimental Forest in central Arizona between 1933 and 1938 were still viable in 1961. Viability ranged from 34 percent with one 1934 collection of vine-mesquite to a low of 3 percent with a 1936 collection of the same species. Species showing no signs of viability in 1961 were green sprangletop, side-oats grama, hairy grama, bullgrass, purple three-awn, fringed brome, plains lovegrass, and wolftail.

Deferment improves semidesert range

Spring-summer deferment of semidesert ranges increased the density and yield of perennial grasses on the Santa Rita Experimental Range, even under relatively heavy grazing. The study was started in July 1962, when the grass stand was at a low point due to drought. Plots near water were subjected to five schedules of deferment:

	Frequency of deferment			
	1 year in 3	2 years in 3	3 years in 4	Every year
Season deferred:				
Summer (July-Oct.)	x	x	x	
Winter (Nov.-Feb.)	x	x	x	x
Spring (Mar.-June)	x	x	x	
Spring-Summer (Mar.-Oct.)	x	x		
Yearlong	x	x		
No deferment (control)				

By July 1966, average perennial grass density on all study plots was 2.7 times as great as when the study started, and perennial grass herbage production in 1966 was 3 times as great as in 1962. The longer periods of deferment (March-October or yearlong) increased grass density most. Recovery was least on areas that were grazed continuously yearlong, and on those that were deferred only during the winter (fig. R-9). Summer deferment was only slightly better than no deferment, but spring deferment increased grass density appreciably.

Herbage yields in most cases were closely related to the average density changes. The exceptions were that spring deferment increased density much more than it increased herbage yield, while spring-summer deferment increased yields by about twice as much as it increased grass density.

These results were obtained near a permanent water where grazing was heavy. More rapid improvement would be expected under moderate utilization.

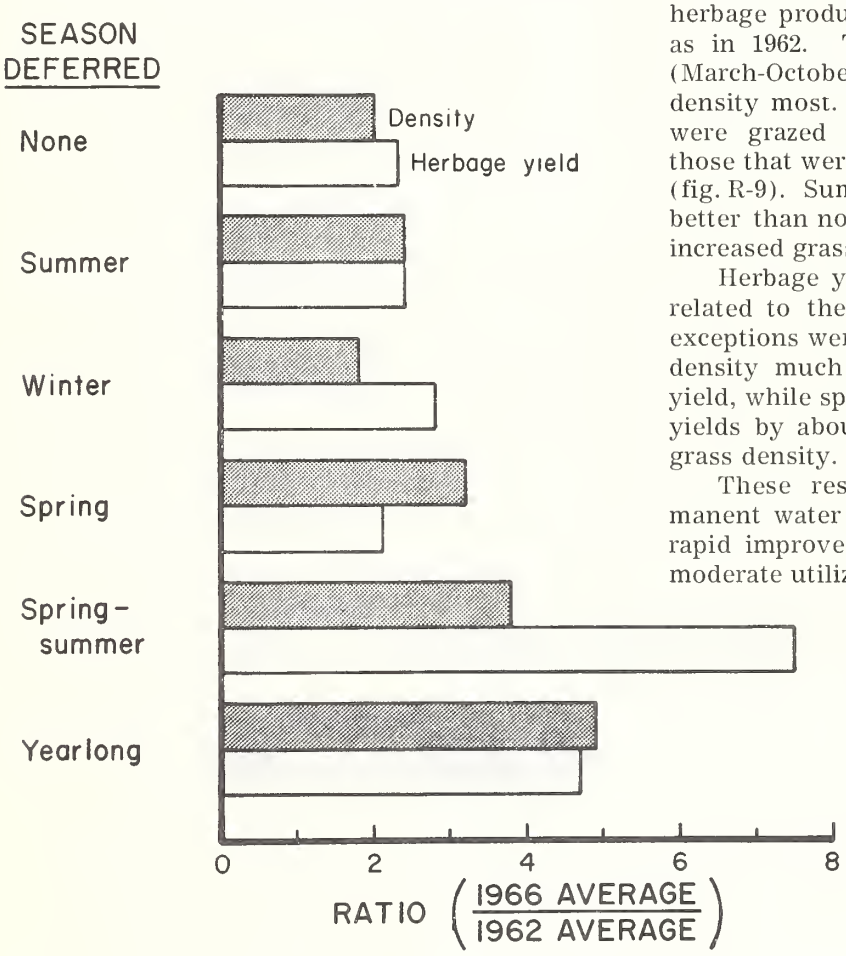


Figure R-9.--Relative increases from 1962 to 1966 in perennial grasses under each period of deferment. Each value in the chart is based on all frequencies of deferment applied to that period.

Wildlife Habitat

Immature stands of ponderosa pine are important bedding areas for deer

In the Southwest, ponderosa pine grows in even-aged groups of from less than one to several acres. According to analysis of deer use evidence, immature age groups (less than 11.5 inches d.b.h.) on the Kaibab plateau were used more than older age groups for bedding by mule deer (fig. WH-1).

Densities of immature tree groups above 160 square feet of basal area were preferred as bedding sites, exceeding other habitat situations by 2 to 10 times.

This finding suggests that not all immature stands of ponderosa pine should be thinned heavily for timber stand improvement where deer production is an important multiple use. Some dense stands of young ponderosa pine should be retained to provide resting areas for deer.

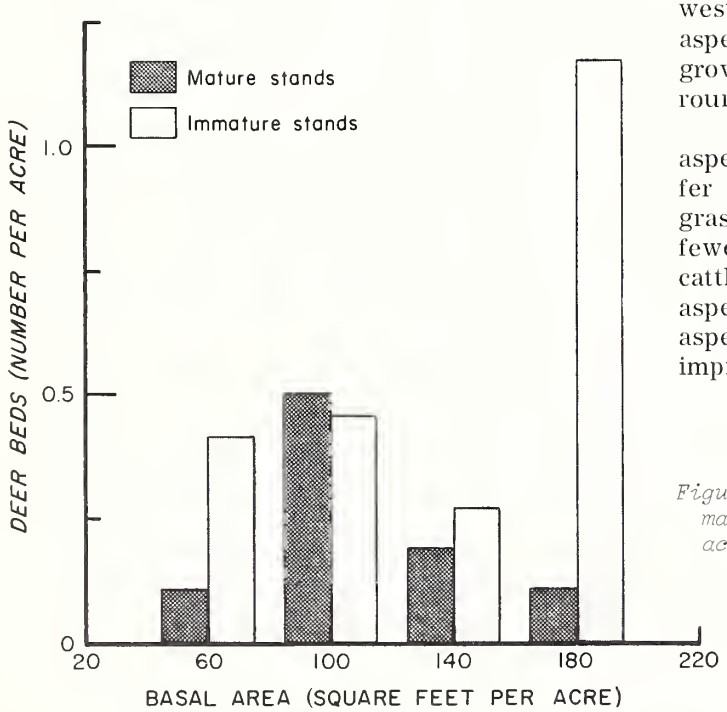


Figure WH-1.--Distribution of deer beds in immature and mature stands of ponderosa pine according to basal area classes.

Deer prefer southern exposures and associated browse in ponderosa pine forests

Two watersheds of approximately 1,000 acres each in a ponderosa pine forest on the Apache National Forest of Arizona were analyzed for use by elk, deer, and cattle on the basis of accumulated dropping groups. No aspect preference could be detected for elk or cattle. Deer use was significantly higher on south slopes, however, and was associated with a greater density of browse. Sixty-one percent of the south slope was dominated by browse.

Steepness of slope (up to 40 percent) did not influence use by deer or elk. Cattle use was higher on the more level areas, however, where herbaceous vegetation was more abundant.

Topographic patterns of use by deer and cattle have an important management implication. If grazing capacity for cattle is based upon proper utilization of the more gentle topography, forage for deer should be sufficient on the steeper slopes.

Aspen groves important habitat segments for deer

When mixed-conifer forests of the Southwest are disturbed by fire or heavy logging, aspen often sprouts prolifically. Deer use aspen groves up to 30 acres in size more than surrounding stands of mixed-conifer forest.

On the Apache National Forest in Arizona, aspen groves outproduced adjacent mixed-conifer forests by 14 times in yield of perennial grasses, and 4 times in yield of forbs; however, fewer aspen sprouts were produced. Deer and cattle dropping groups were more numerous in aspen groves (fig. WH-2). An interspersion of aspen groves in a mixed-conifer forest should improve habitat for deer.

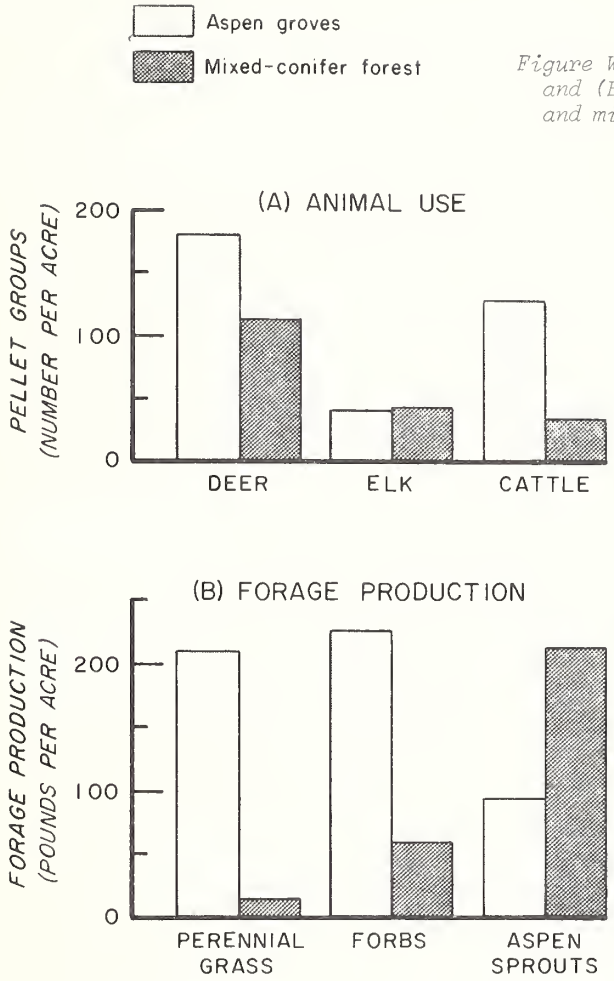


Figure WH-2.--Comparison of (A) animal use, and (B) forage production of aspen groves and mixed conifer forest.

Mule deer use different aspects on cleared and natural chaparral areas

Seasonal pellet-group counts on cleared and adjacent natural chaparral west of Prescott, Arizona, revealed that mule deer prefer south-facing aspects on cleared areas and north-facing exposures in natural brush. Chaparral was cleared by rootplowing, and seeded to perennial lovegrasses (fig. WH-3).

Deer use was highest from April through June. Evidently, new growth of forbs and grasses attracted deer during this season before such forage became available at higher elevations.

Because of small size of converted areas (80 acres), use differences associated with distance to cover were not apparent. Total annual use on grass-developed areas was about three-fourths that on untreated brush—7.6 versus 10 deer per section.

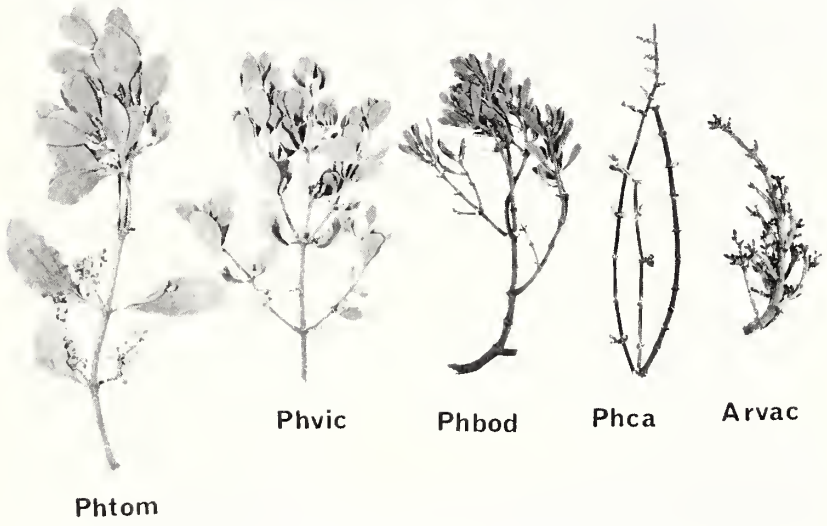
Figure WH-3.--Root-plowed areas (light color) seeded to perennial grass in Arizona chaparral. Mule deer prefer south-facing aspects on cleared areas and northerly exposures in natural brush.

Mistletoe species used by deer in Arizona have different nutritional values

Nutrient deficiencies may develop among deer forages in southwestern chaparral at various seasons. Phosphorus deficiency is suspected. Previous studies of mistletoes parasitic on junipers and oaks indicated comparatively high yearlong phosphorus content and palatability to deer. Accordingly, five species of mistletoes in Arizona (fig. WH-4) were analyzed to determine if they could contribute significantly toward deer nutritional requirements.

Mistletoes varied seasonally in crude protein and phosphorus content. Phosphorus levels were fairly constant, but high only in **Phtom** and **Arvac**. The calcium:phosphorus ratio, not wide in any species, was remarkably low in **Arvac** and **Phvic**. Crude protein was adequate in only **Phca** and **Phtom**. Nutritional content of the parasite exceeds but parallels that of the host.

Figure WH-4.--Species of mistletoes analyzed for nutritional values.



Symbol	Mistletoe	Host
Phtom	*Phoradendron tomentosum* (DC.) Engelm. subsp. *macrophyllum* (Cockerell) Wiens	Cottonwood
Phvic	*P. villosum* Nutt. subsp. *coryae* (Trel.) Wiens	Shrub live oak
Phbod	*P. bolleanum* (Seem.) Eich. subsp. *densum* (Torrey) Wiens	Arizona cypress
Phca	*P. californicum* Nutt.	Paloverde
Arvac	*Arceuthobium vaginatum* (Willd.) Presl subsp. *cryptopodum* (Engelm.) Hawks. & Wiens	Ponderosa pine

Clearcutting narrow strips in lodgepole and spruce-fir timber improves deer habitat

Use by mule deer doubled after lodgepole pine and spruce-fir timber in Colorado was clearcut in strips 1 to 6 chains wide (fig. WH-5).

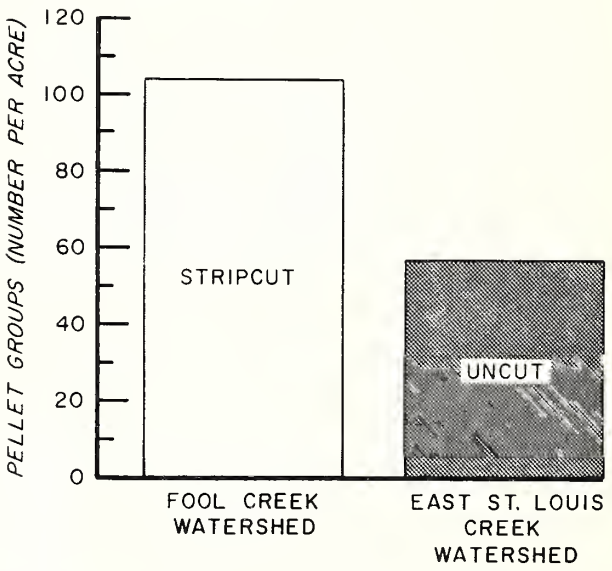


Figure WH-5.--Average use by deer of spruce-fir and lodgepole pine forests, Fraser Experimental Forest.

Use increased principally in the openings: Pellet-group densities in the intervening uncut strips remained essentially unchanged, while they tripled in the openings (fig. WH-6). Openings 2 and 3 chains wide were used more than openings 1 and 6 chains wide.

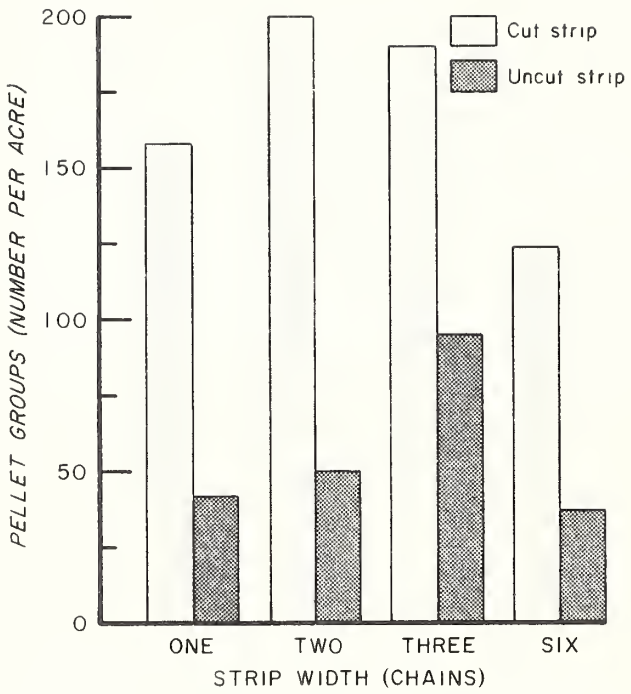


Figure WH-6.--Effect of width of cutting strip on deer use in lodgepole pine and spruce-fir forest, Fool Creek Watershed, Fraser Experimental Forest.

Snow depth determines extent of sagebrush winter range of deer

On the big sagebrush type in central Colorado, the availability of winter mule deer range is governed by snow depth. In Middle Park, snow over 1½ feet deep precluded deer use (fig. WH-7). Exposed cover of shrubs was reduced 80 percent by 12 inches of snow and 90 percent by 16 inches of snow (fig. WH-8). On one area studied, the available winter range in two heavy winters was reduced to less than 2 percent of that available in a relatively open winter. Means of alleviating sagebrush winter range problems are being investigated cooperatively with the Colorado Game, Fish, and Parks Department.

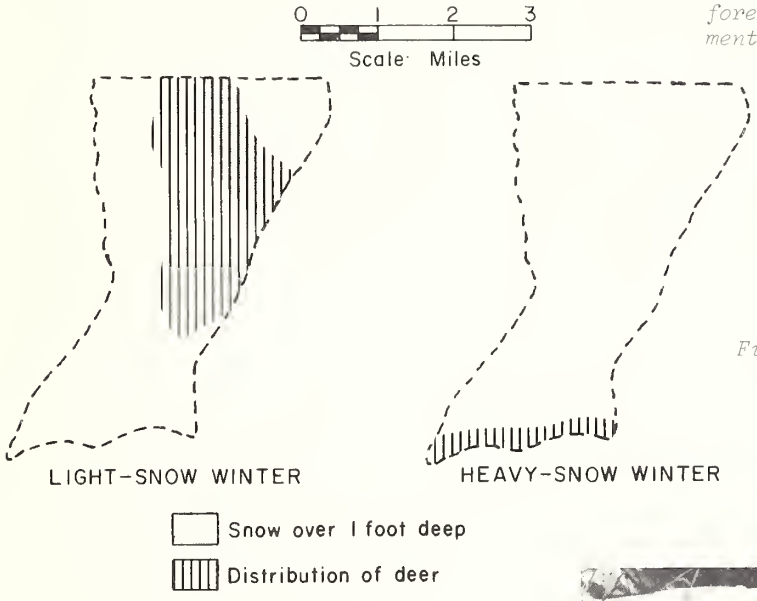


Figure WH-7.--Effect of snow on distribution of deer on Colorado winter range study area.

Figure WH-8.--Browse available for deer is determined by depth of snow cover.

Planted shrubs show good survival under ponderosa pine

Chokecherry has survived best in an open stand of ponderosa pine in the Black Hills of South Dakota. Other browse species offering promise for planting under the pine are American plum, silverberry, Siberian pea shrub, Russian-olive, and silver buffaloberry.

Transplants surviving best on the McVey Burn are Siberian pea shrub, chokecherry, and American plum. Russian-olive has almost completely died out over a 3- to 4-year period on the Burn site.

In general, early survival has been much better under the open pine canopy than on the exposed Burn site (fig. WH-9).

Growth of Siberian pea shrub improved by deer browsing

Shrub adaptability studies in the Black Hills of South Dakota have indicated the possible use of Siberian pea shrub for planting under ponderosa pine to provide valuable browse for deer, and buds and seeds for grouse and turkey. Observations on caged and uncaged plants have shown that shrubs browsed by deer regrow vigorously (fig. WH-10).

In a related study to determine the effect of simulated browsing on twig numbers and dry matter production, Siberian pea shrubs with 50 percent of each twig removed produced 60 percent more annual twig growth than untreated plants during each of 2 years of treatment.

Telemetry helps determine grouse habitat preferences

Wildlife habitat researchers were able to follow the movements of sharp-tailed grouse by use of a radio transmitter (fig. WH-11). Radio telemetry is a valuable tool for determining specific habitat requirements of sharp-tailed grouse and greater prairie chickens. Its greatest potential may be in locating grouse during their nesting and roosting activities. Habitat preferences for both these activities are as yet mostly unknown.

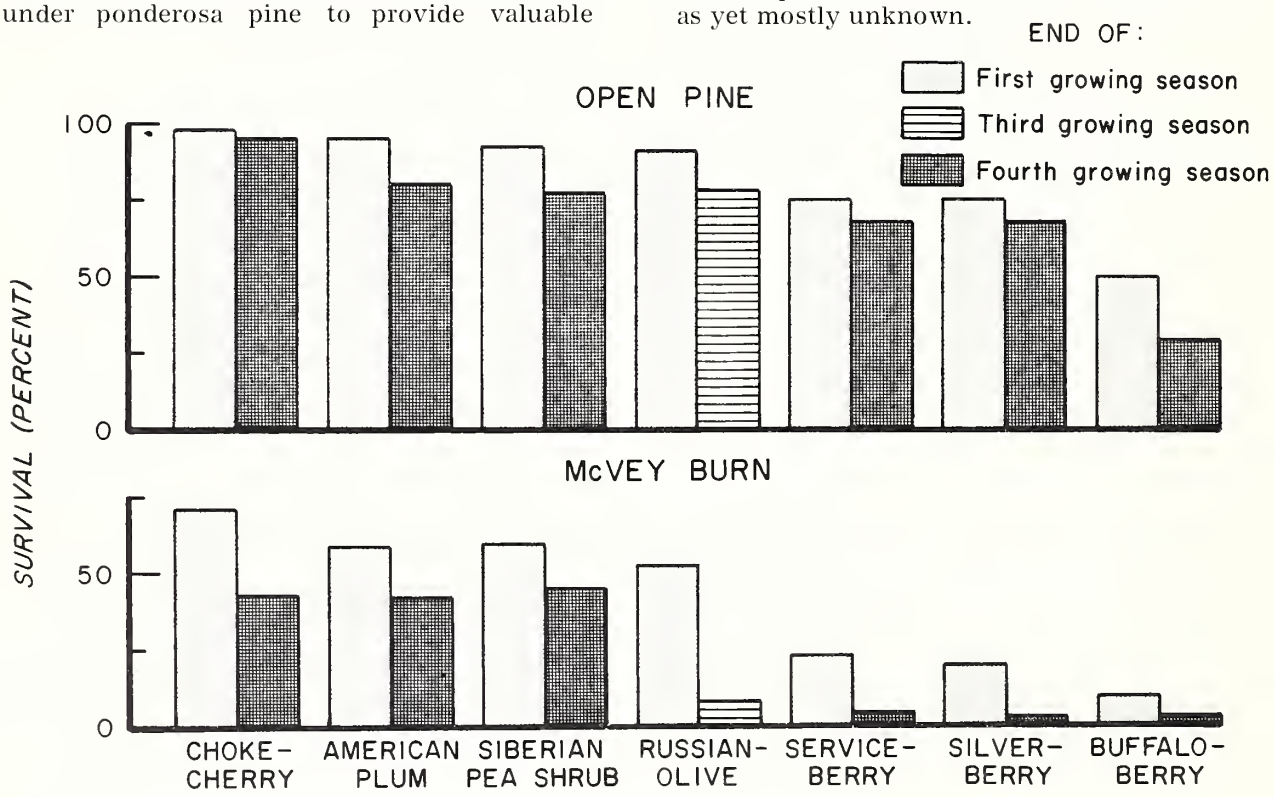


Figure WH-9.--Percent survival of nursery stock planted under an open pine stand and on the McVey Burn after the first and fourth growing seasons. (Survival for Russian-olive is for the first and third growing seasons.)

Figure WH-10.--Over a 9-year period, Siberian pea shrub, protected from deer browsing by a wire cage (left) produced little available forage, but when heavily browsed yearly by deer (right) produced an abundance of edible twigs and seeds.

Figure WH-11.--Movements and habitat use of sharp-tailed grouse equipped with a radio transmitter were determined, using a trail cycle and portable receiver with a directional antenna.

Miniature radio transmitter, complete with battery, whip antenna, and potting material, is mounted in a leather harness, then attached to a grouse.

Sharp-tailed grouse eat diverse foods

Analysis of crops from 188 sharp-tailed grouse collected in the short-grass and mixed-grass plains of southwestern South Dakota show that their food habits vary with season, and include a variety of material (table WH-1).

Plant material predominated in the diet throughout the year, but animal matter, principally grasshoppers, comprised 24 percent of the summer diet. Fruits of hawthorn, western snowberry, and rose, and cultivated crops were the principal fall and winter diet. Winter buds from Russian-olive and cottonwood were also important. During the spring months, forbs, principally dandelion, were preferred.

These results were obtained from the first year of a 2-year study conducted cooperatively with South Dakota State University and the South Dakota Department of Game, Fish, and Parks.

Table WH-1.--The most utilized food items by percent volume for each season observed in crops of 188 sharp-tailed grouse in southwestern South Dakota

Food item	Percent volume	Food item	Percent volume
SPRING		SUMMER	
Dandelion	59.8	Insects	24.1
Rose	7.4	Cultivated crops	20.5
Insects	2.5	Rose	15.5
Western snowberry	.6	Prickly lettuce	5.3
Others	29.6	Western snowberry	5.2
		Others	29.4
FALL		WINTER	
Cultivated crops	25.6	Cultivated crops	55.8
Western snowberry	20.0	Western snowberry	17.7
Hawthorn	7.3	Rose	7.4
Rose	5.8	Russian-olive	4.7
Grass blades	3.5	Cottonwood	1.6
Insects	3.1	Others	12.8
Others	34.7		

Forest Biology

(In cooperation with the Fish and Wildlife Service, U. S. Department of the Interior)

Pocket gopher populations in relation to grazing

Estimates of fall populations of the northern pocket gopher inhabiting grazed Thurber fescue-forb range at Black Mesa Experimental Forest and Range, Colorado, have varied only between 16 and 20 animals per acre for the past 5 years. The population was determined by trap-outs (fig. FB-1) and counts of gopher mounds and earth plugs on 1-acre sample plots.

The pocket gopher is being studied on high mountain grasslands to learn how it affects plant composition, forage production, soil properties, and watershed values.

The study is also providing information on pocket gopher life expectancy, population turnover, reproductive season, growth of young, and nutritional aspects of the herbivorous diet of these rodents.

Figure FB-1.--Live-trapped pocket gophers were marked with monel metal leg bands, released, and retrapped to study population trends on grazed ranges.

Reproductive period of northern pocket gophers delineated

The period of the year when young pocket gophers are born at 10,000-foot-high Black Mesa Experimental Range, in Colorado, may extend from February 15 to August 15, a 6-month period. However, 75 percent are born between May 15 and July 15. These percentages were determined by using the capture date and weight of young animals and back dating, by use of a growth curve based on weight, to the day of parturition.

Nutrition of northern pocket gopher studied

Stomach samples taken from pocket gophers showed that percentage composition of protein, fat, calcium, and phosphorus, did not change measurably between years. However, gross energy and carbohydrates tended to show slight differences. The samples were taken from pocket gophers collected at Black Mesa Experimental Range in fall, 1962 through 1966, and at Grand Mesa, 1963 through 1966.

Nutrients were measured to learn if there was a relationship between nutrient composition of the diet of the herbivorous pocket gopher and size of population. Reasons for population changes are often obscure. Some recent population studies have been exploring the quality and quantity of available food as an explanation for change in animal populations.

When gross energy and carbohydrate values were compared with pocket gopher population levels by years, there appeared to be an inverse relationship. Values for gross energy and carbohydrate tended to be largest when populations were smallest, which suggests there was a higher energy diet available to pocket gophers when the number of animals per unit area was small.

Population changes of montane voles and deer mice in relation to grazing

Populations of montane voles and deer mice are being studied along with pocket gophers in relation to grazing on Black Mesa. The 1967 population of montane voles, estimated by live-trap and snap-trap sampling, was the smallest recorded since 1963 (0.1 vole per acre). The largest population was two per acre in 1965.

Figure FB-2.--Live-trapped deer mice were ear-tagged, released, and retrapped to determine their abundance on grazed ranges.

The population of deer mice in 1967 numbered 1.3 per acre, (fig. FB-2) an increase from 0.6 in 1966. Causes for population changes in deer mice are being studied in relation to grazing intensity, precipitation, and other factors.

Merriam's turkeys prefer small openings for feeding

On a study area characterized by an overstory of ponderosa pine, juniper, and Gambel oak, 145 observations were made that included 1,314 turkeys in 1966. Observations were classified according to habitat segments as follows:

	Number of observations	Percent occurrence
Habitat segment:		
Opening (less than 50 yards from cover)	68	46.9
Mixed ponderosa pine, oak and juniper overstory	38	26.2
Ponderosa pine overstory	20	13.8
Opening (more than 50 yards from cover)	11	7.6
Juniper overstory	5	3.4
Oak overstory	3	2.1
Total	145	100.0

Small openings (less than 100 yards across) are clearly important feeding areas for Merriam's

Figure FB-3.--Small forest openings are important feeding areas for Merriam's turkeys. Fifty percent of observations of 1,314 birds in 1966 were within 50 feet of the forest edge. (Photograph by Arizona Game and Fish Department)

turkeys. Nearly half of the observations were made in such situations (fig. FB-3). Also, most turkeys observed more than 50 yards from cover in larger openings were crossing rather than feeding in the opening. These findings emphasize the importance of small openings under coniferous forest conditions for supplying the habitat needs of Merriam's turkeys.

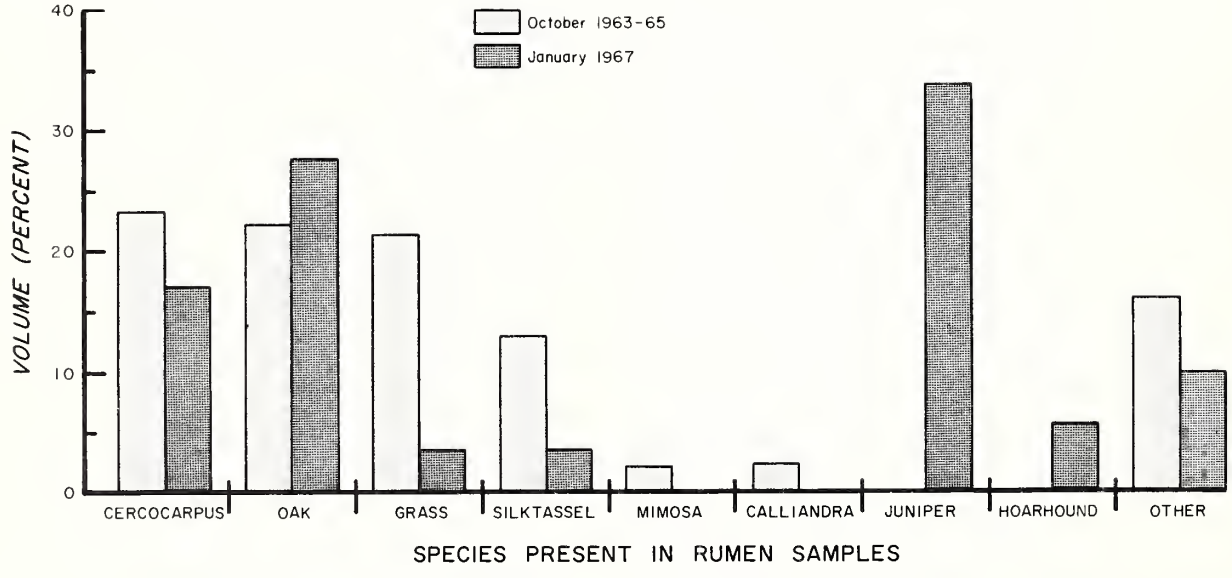
Juniper berries important to elk when available

Food items of importance in elk rumen samples taken from a pinyon-juniper area near Silver City, New Mexico, in 1963-65 were cercocarpus, 23 percent; acorns and leaves of oak, 22 percent; grasses, 21 percent; and silktassel, 13 percent. The "other" category of more than 15 percent included a dozen identifiable groups, plus unknown items (fig. FB-4).

In 1967, unusual fruiting of juniper shifted food preferences some. Juniper fruits and leaves were most abundant in rumens (34 percent volume), oak was second (28 percent), and cercocarpus dropped from first to third.

This comparison suggests the importance of availability of food items in the feeding habits of elk. To have a full appreciation of the feeding habits of elk from rumen analysis, seasonal and annual replications will be necessary.

Figure FB-4.--Fourteen elk rumen samples, collected near Silver City, New Mexico in October 1963-65 and 13 in January 1967, were analyzed. A few major plant species comprise the bulk of food items of elk in the pinyon-juniper type. Juniper was an important food item in 1967.



Watershed Management Research

Wind velocity profiles upwind of snow fences

Snow fences have proved effective in increasing snow depth on some alpine snowfields. In some instances, however, these fences become buried in the snowdrift, which damages the fence. Determining the proper location of these large snow fences is a major problem.

Wind velocity profiles were measured at several stations upwind of snow fences on two alpine ridges. At one site, the fence became buried; the other fence did not (fig. W-1). The profiles showed a reduction in wind velocity near the ground as flow approached the fence that was buried. Flow accelerated slightly approaching the fence that did not become buried. The reduction in velocity in front of the fence which was buried was related to a slight downward ground slope between the top of the ridge and the fence. Preliminary data indicate that fences located even slightly leeward of ridge crests tend to be buried by the snowdrift.

Figure W-1.--This fence was not buried by a windward drift. Wind speeds were measured at several elevations above the ground on both masts located to the windward of the fence. Snow behind the fence did not melt out completely during the summer of 1965.

Snow pack depletion-runoff relations show promise for streamflow forecasts

Aerial photography is being used to observe snow-cover depletion in the central Rocky Mountains (fig. W-2). Observations show that snow-

Figure W-2.-- Considerable snow has already disappeared from the south slope on Deadhorse Creek, (right), whereas Lexen Creek (left) is completely snow covered. Snow-cover depletion on Lexen Creek lags depletion on Deadhorse Creek by approximately 9 days.

cover depletion rates are highly correlated with seasonally generated runoff volumes (fig. W-3). Also, depletion-runoff relationships do not vary appreciably from year to year in spite of variability in (1) the amount of snow, and (2) weather conditions which produce runoff. At any given location, annual patterns of snow depletion are consistent, as is the snow-cover depletion on one watershed relative to another.

We foresee that observations of snowpack depletion can be effectively used in basic studies of the snowmelt process. Such data are currently being applied successfully in river basin management. Also, depletion-runoff relationships offer promise for making accurate short-term streamflow forecasts for power production, irrigation, and municipal use.

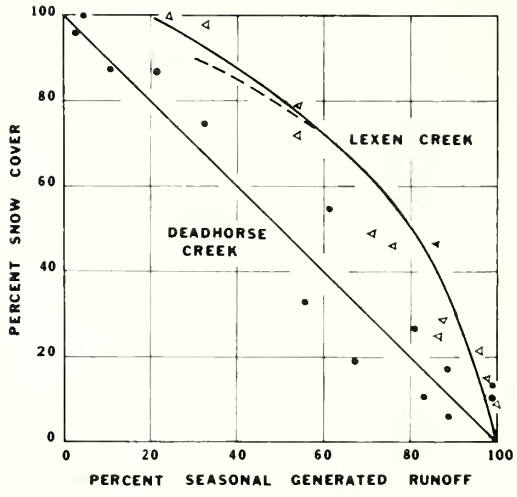


Figure W-3.--Depletion-runoff relationships for Deadhorse and Lexen watersheds. On Lexen Creek, about 20 percent of the runoff is generated before depletion of the snowpack begins.

Free water seepage induced by clearcutting, but not thinning, in second-growth ponderosa pine

Thinning in a dense, second-growth pine stand in the Black Hills from 190 square feet basal area in 2,000 trees per acre to 80 square feet basal area and 435 trees per acre did not induce free water seepage to ground water (fig. W-4). Actual increase in seepage depends on enough incoming moisture to overcome the soil-moisture deficits, which were greater at the end of each of 5 years of study in the unthinned than in the thinned stand. Clearcutting and maintenance in bare soil condition induced free water seepage even in relatively dry years. Subsequent establishment of a weed stand followed by Kentucky bluegrass reduced seepage yield potential, but it remained higher than in the thinned and unthinned portions of the stand due to less capacity for moisture depletion from the entire soil mantle.

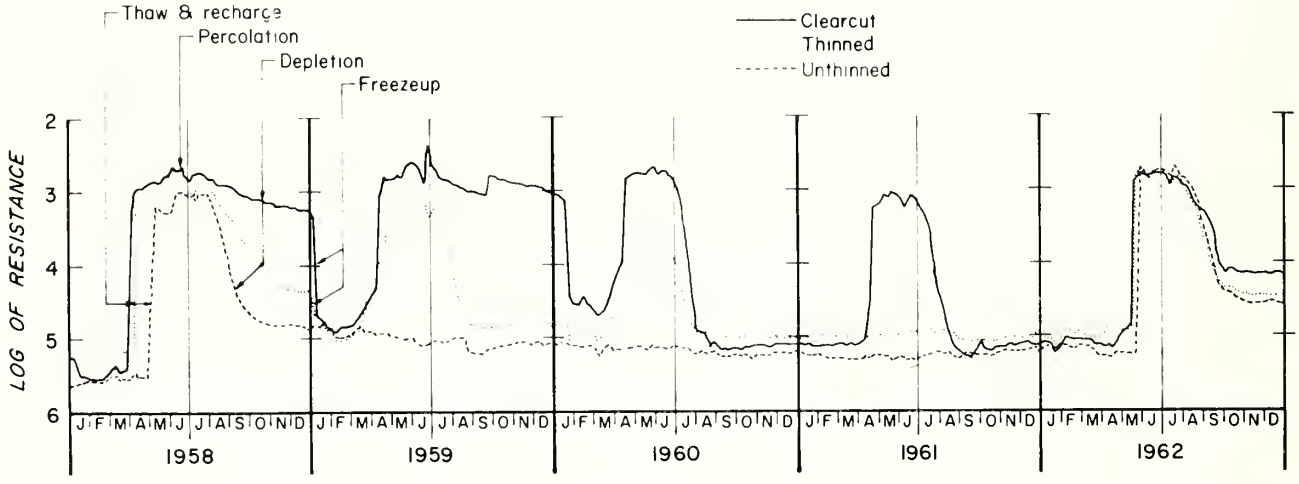


Figure W-4.--Moisture trends in the 18- to 30-inch level as indicated by log resistance readings of fiberglas units. Log of resistance readings provide a better basis for comparison of treatment trends than moisture contents based on questionable calibrations. Retention capacity is about log resistance 3, and wilting point is about log resistance 5.

Sagebrush control affects soil-moisture use

Soil moisture response to herbicidal control (2, 4-D) of big sagebrush was evaluated during a 5-year study near Dubois, Wyoming.

Sagebrush kill of about 90 percent on sprayed plots resulted in about a 100 percent increase in grass production the second year after treatment. Total herbage yields the second and third years after spraying were not significantly affected by the treatment.

Although soil moisture levels generally were not significantly different between treatments, soil-moisture withdrawal rates the second and third years after treatment were greater under natural sagebrush cover than under treated plots. About 75 percent of the difference in total depletion occurred within the 3-6 foot soil depth. A reverse effect in the second foot indicated that the increase in grass herbage production was most strongly reflected in that zone, total root activity there being increased as a consequence of vegetative conversion. Very little difference between treatments was observed below 6 feet, the depth of average maximum root penetration of big sagebrush in the area.

The second year after spraying, total evapotranspiration for the period June 24 to October 29 was about 14 percent less on sprayed than on control plots.

Measurements indicated big sagebrush did not use a detectable amount of water during the winter. Soil moisture recharged earlier on sprayed than on control plots on a west-facing slope because of greater snow accumulation on unsprayed sagebrush, and shading of the snow by live sagebrush crowns.

Water yields from treating North Fork Workman Creek have increased most during winter

On the North Fork watershed of Workman Creek in Arizona, one-third of the forest vegetation, principally fir, was converted largely to perennial grass and forbs. This conversion resulted in a highly significant increase—about 44 percent—in water yield. Workman Creek is both rain and snow fed. In many years, winter rains will cause flooding and produce relatively high water yields. Other years a snowpack of up to 16 inches water content may accumulate. The original analysis to test the effectiveness of treatments considered only annual runoff. The average monthly discharges, however, better describe the treatment results (fig. W-5).

Maximum increases occurred in February and March. Eighty percent of the increase occurred during the 8 winter months, and only 20 percent during the 4 summer months of June to September. Thus, the larger increases occur during the snowmelt and winter flood periods, which gives greater direct benefit than during the summer season. These increases are relatively in proportion to the amount of flow during the two periods.

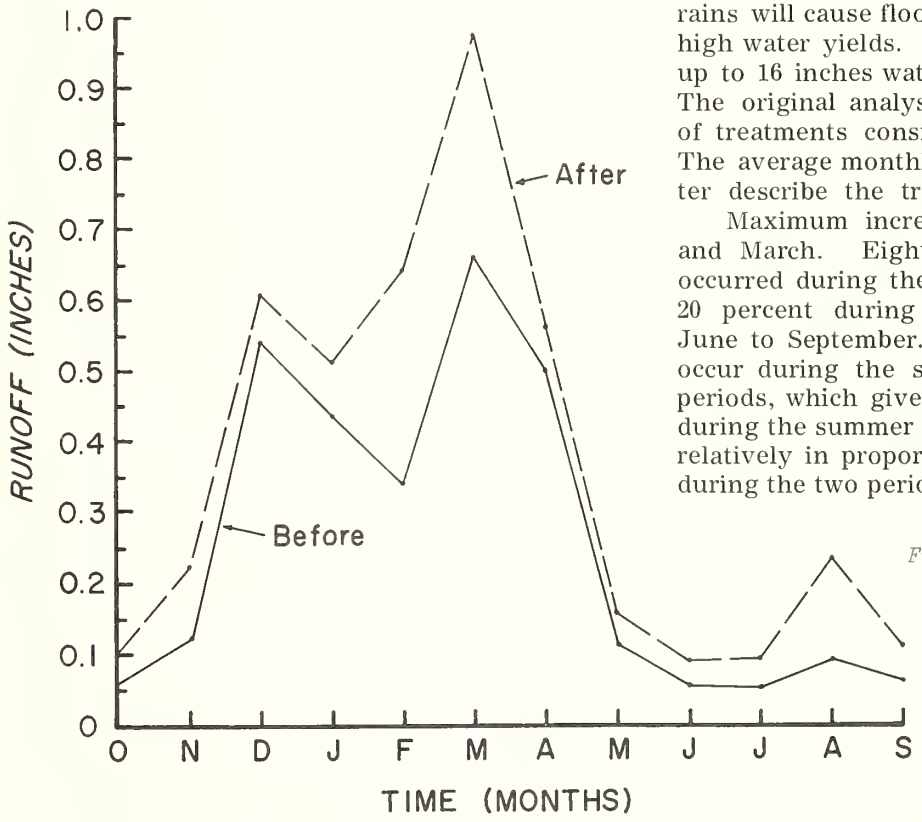


Figure W-5.--Average monthly discharge before treatment (1939-58) and after treatment (1959-66) on North Fork Watershed of Workman Creek, Arizona.

Even-aged management "goal" for improving water yield

Treatment in Castle Creek in Arizona toward even-aged management of ponderosa pine as a method for improving water yields was essentially completed by the end of the 1966-67 water year. Net timber harvested was 6,300 board feet per acre. Approximately 900 cords of pulpwood have been cut and 331 acres thinned. Weeding has been completed on the clearcut areas, which comprises one-sixth of the watershed area.

Picloram treatment of a watershed can influence water quality

Picloram (4-amino-3, 5, 6-trichloropicolinic acid), a potent herbicide effective against a broad spectrum of forbs and woods plants, was used in a chaparral watershed treatment to determine the effect of partial elimination of brush on water yield and sediment production. The treatment consisted of chemically treating all shrubs, with the exception of the most desirable browse species, on northeast-facing slopes. Picloram pellets (9.3 pounds acid equivalent per acre) were applied to a 2-acre side drainage of a 46-acre watershed. Detectable amounts of picloram moved into the stream water. The highest concentration, 0.37 p.p.m., occurred after a 2.53-inch rainstorm 5 days after treatment (fig. W-6). Since the picloram-treated drainage represented only 4.5 percent of the total area of the watershed, there was a possible 22-fold dilution in the measured concentration of picloram. The extent of movement of picloram into the stream water was related to rainfall duration and amount. After 40 inches of rain during a 16-month period, picloram was no longer detected in the stream water.

Picloram is low in toxicity to a variety of test animals, including avian, mammalian, and aquatic species, and does not represent a hazard

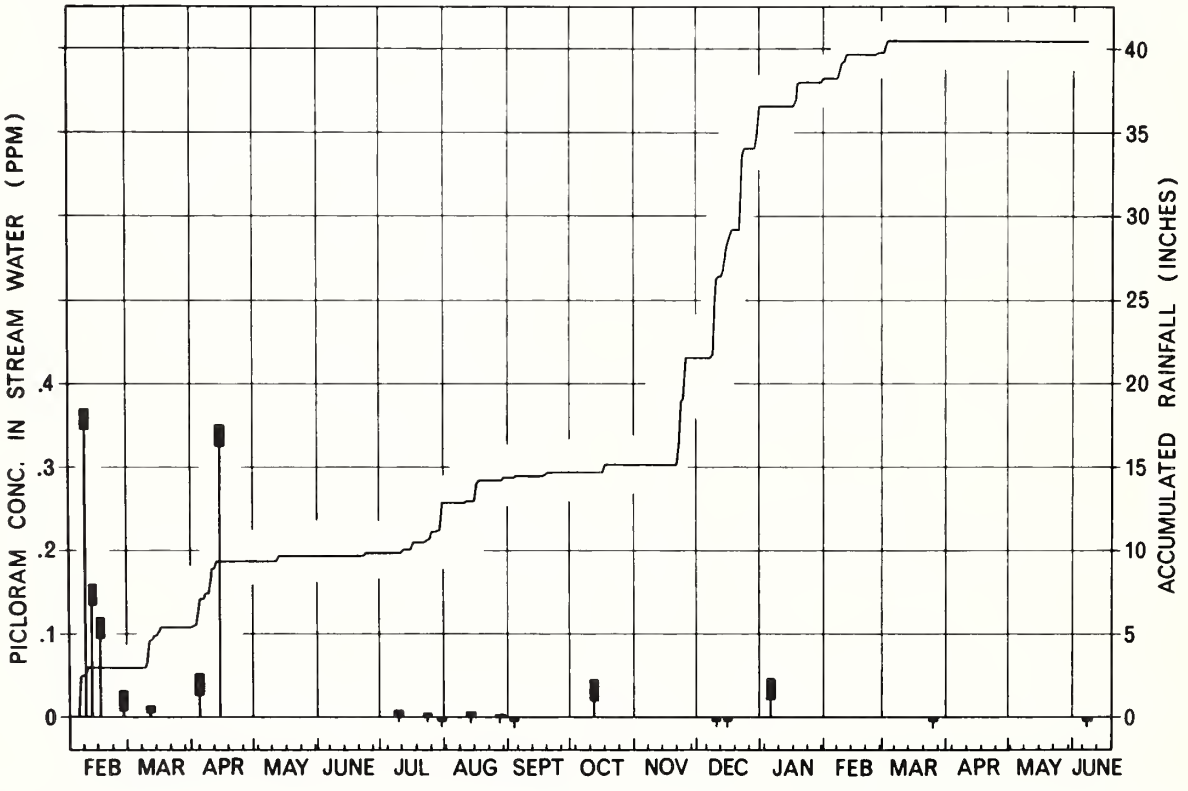


Figure W-6.--Picloram concentration in the stream water from watershed B, and accumulated rainfall, measured at base of watershed, during a 16-month period after treatment. Picloram was applied on February 1, 1965.

to livestock or wildlife when used as recommended. Although picloram-contaminated water for irrigation purposes could cause damage to sensitive crops, water from treated areas generally would be vastly diluted with water from untreated areas.

The extent of contamination caused by picloram treatments can be expected to vary with location, and will depend upon size of area treated, amount of chemical applied, type of application (soil or foliage), soil type and properties, topography, and precipitation.

Selective shrub control improves water yield as well as wildlife habitat

Perennial streamflow has resulted from a hand application of fenuron and picloram to selected chaparral shrubs on 40 percent of a 46-acre watershed at Three Bar in central Arizona. Treatment was confined to northerly slopes and channel bottoms. Preferred deer browse shrubs, comprising 7 percent of the cover, were left untreated. Chemical treatment of the predominantly oak-mountainmahogany vegetation reduced total cover from 51 to 12 percent, while that on untreated southerly slopes and ridgetops gradually increased.

Although chemical was applied in January 1965, no change in the characteristic ephemeral flow was evident until the heavy rainfall of the following November and December. Flow then increased sharply. For the water year ending June 30, 1966, water yield increased 7 inches over the area treated. For the much drier water year ending June 30, 1967, the increase was approximately 2 inches over the area treated.

Shrub control on cool, more moist sites with interspersed southerly aspects left as escape cover and browse forage promises to be a highly desirable treatment to improve deer habitat.

Shrub live oak exceeds true mountainmahogany in leaf mass

Large shrub live oak plants—those with a volume index of 200 cubic feet or more—may have from 63 to 73 percent more leaf mass than comparable sized true mountainmahogany shrubs (fig. W-7). If water use is correlated

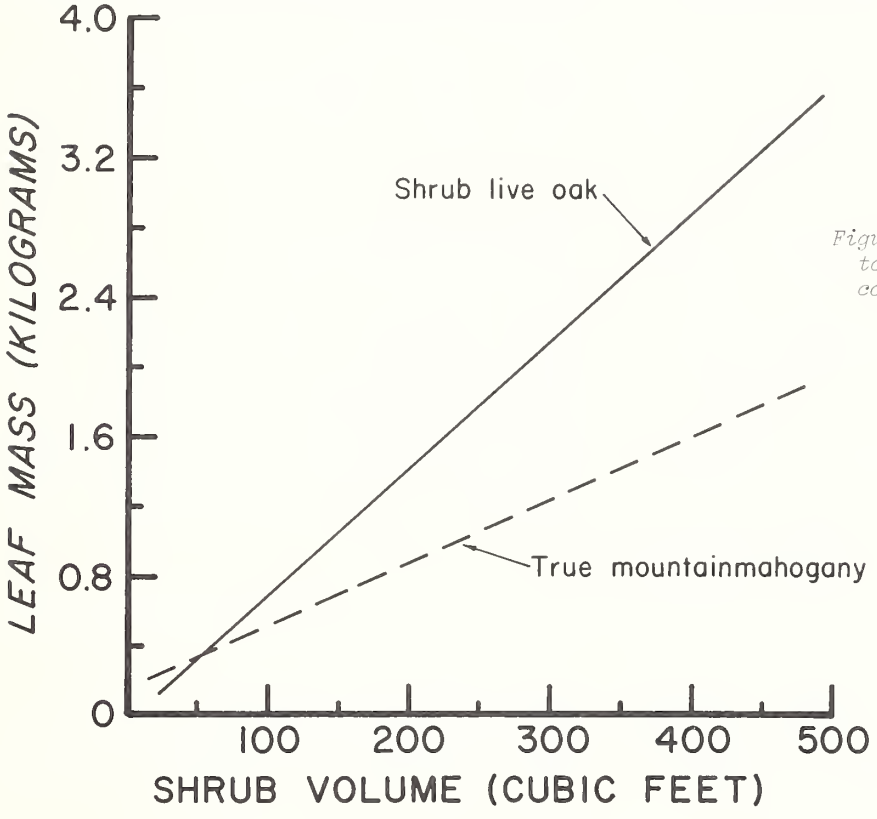


Figure W-7.--Leaf mass in relation to shrub size (volume) for two common chaparral shrubs.

with leaf mass and leaf area, this greater leafiness represents another strike against the relatively unpalatable shrub live oak. Both shrubs are deep rooted. Shrub live oak produces an abundance of hard, spiny leaves in most years, while true mountainmahogany has a more open, spindly growth form with smaller, hairy leaves.

Fall-burned chaparral watershed produces sediment

Burning one-fourth of a chaparral watershed each fall in strips of various widths resulted in significant soil loss, compared to an unburned check. Erosion appeared more dependent on rainfall and local topographic changes than upon strip widths of 50, 100, or 200 feet. Sediment movement into storage basins began during a high rainfall period about 2 years after the burning program started. Sediment was still flowing intermittently 2 years after burning was completed.

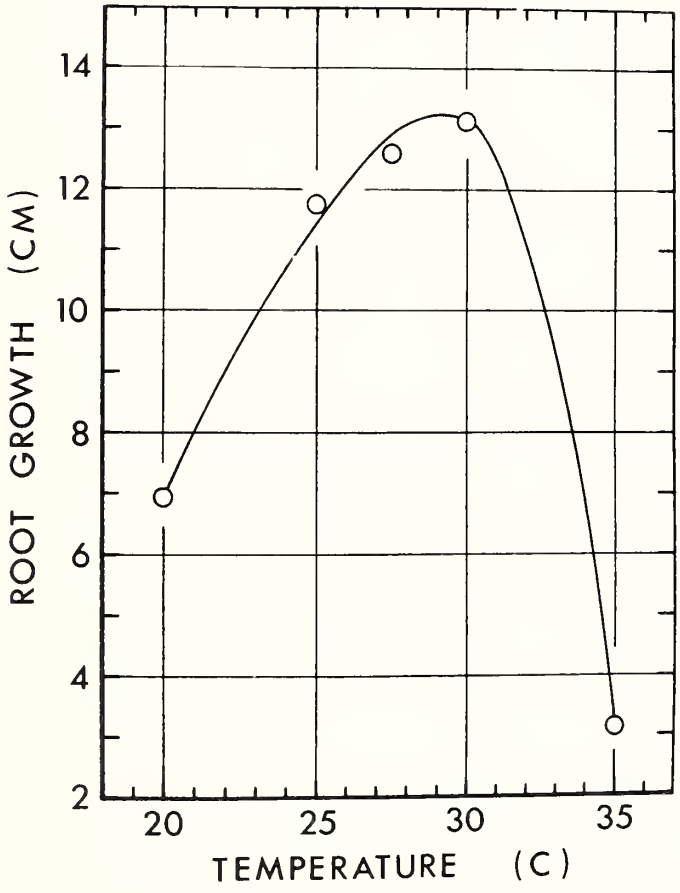


Figure W-8.--Root growth of pregerminated acorns of shrub live oak in response to temperature. Data for two growth periods (7 and 10 days) were pooled to give a single growth-response curve. Each point is the mean of 60 measurements.

Rooting temperature vital for propagation of shrub live oak

Shrub live oak is one of the most difficult native shrubs to manage in the field. Also, its reproductive characteristics make it difficult to study in the laboratory.

Softwood cuttings of shrub live oak were rooted in a laboratory chamber supplied with intermittent mist, 1,600-foot candles illumination, 30°C. rooting-medium temperature, and 25°C. air temperature. Rooting-medium temperature was selected by means of a temperature vs. root-growth response curve for germinating acorns (fig. W-8). This method should be useful with difficult-to-root cuttings whose environmental requirements are more exacting than those for easily rooted cuttings.

An average of 75 percent of both soft fully expanded and hardened cuttings (taken at the completion of a flush of growth) rooted in a 1:1 mixture of perlite and peat moss; the overall rooting percentage for these cuttings in six different media was 51 percent. Soft fully expanded and hardened cuttings were superior to succulent cuttings in the elongation stage. A 1:1 mixture of perlite and peat moss was superior to perlite alone as a rooting medium. Although 3-indolebutyric acid aids rootings of many cuttings, repeated foliage sprays on the cuttings in the rooting chamber did not increase rooting of shrub live oak.

A new laboratory chamber for rooting cuttings

In the field of root initiation, a laboratory rooting chamber can serve a role similar to that of the plant growth chamber in the fields of growth and flowering. An apparatus has been built that permits research on the rooting behavior of plants without greenhouse facilities irrespective of season. Features of the rooting chamber include (fig. W-9): small size (it is

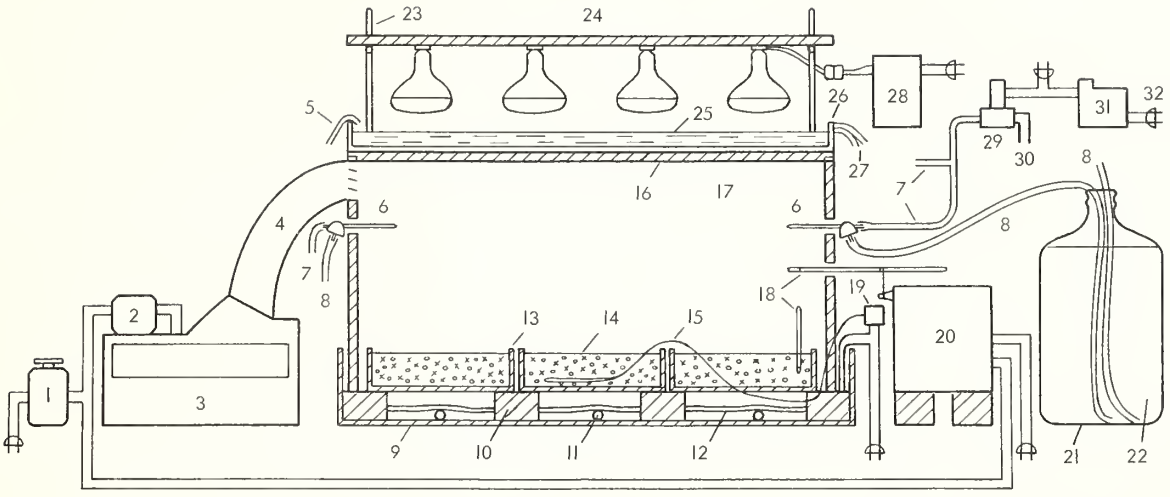


Figure W-9.--Diagram of the laboratory chamber for rooting cuttings. Components of the apparatus are:

1. *variable transformer*
2. *AC to DC transformer*
3. *evaporative cooler*
4. *air duct*
5. *tap water inlet tube*
6. *atomizer*
7. *compressed air line to atomizer*
8. *distilled water line to atomizer*
9. *drainage pan*
10. *brick support for enclosure and rooting-medium trays*
11. *pipe support for heating cable*
12. *lead-sheathed heating cable*
13. *rooting medium tray*
14. *rooting medium*
15. *capillary temperature-sensing probe*
16. *wooden frame of enclosure*
17. *vinyl plastic covered enclosure*
18. *mercurial thermometer*
19. *thermostat for heating cable*
20. *Thermocap Relay*
21. *5-gallon bottle*
22. *distilled water*
23. *support stand*
24. *bank of 300-watt incandescent reflector flood lamps*
25. *flowing tap water*
26. *clear Plexiglas tray*
27. *water outlet tubes*
28. *timer for lamps*
29. *solenoid valve*
30. *compressed air inlet*
31. *cam recycling timer*
32. *115-volt AC input*

designed for a laboratory bench), a plastic-covered enclosure, an intermittent mist system, incandescent illumination, a running-water bath filter for removing infrared radiation emitted by the lamps, day-length control, air-temperature control, and rooting-medium temperature control. Venturi-type atomizers draw distilled water from a reservoir to which nutrients, growth substances, vitamins, antibiotics, and other items can be added.

Watershed rehabilitation in the Southwest

On three watersheds in the semidesert area of New Mexico, average annual sediment declined an average of 0.5 acre-foot per square mile after grazing on the watersheds was deferred during summer. This management, aimed at 55 percent utilization by weight of alkali sacaton, resulted in ground cover doubling, bare soil decreasing and runoff staying about the same compared with a previous period of yearlong grazing.

Ripping one watershed (fig. W-10) initially resulted in a 28 percent loss of perennial grass ground cover, 50 percent loss of litter, and a 24 percent increase in bare soil. Total forage production reached 476 pounds per acre 2 years after treatment, the highest recorded in 10 years of study. This watershed produced no runoff the first year after treatment, and about one-half as much as would otherwise be expected 1 year later. Sediment production averaged 0.5 acre-foot per square mile per year, or 1.21 tons per acre per year for 7 years before treatment—none after treatment.

Figure W-10.--
Ripping was accomplished with a Jayhawk Soil Ripper on the contour. Spacing was 7 feet apart and 30 inches deep.

Protection from grazing for 2 years did not increase the ground-cover index or forage production on another watershed, but increased litter over 300 percent.

Germination of alkali sacaton is affected by the time of day when seeded

The time of day when seeds are placed in the germinator seems to affect the germination rate of alkali sacaton. Seeds were put in a germinator at 8 a.m., 12 noon, 4 p.m., and 12 midnight under the temperature-light regime previously determined to be best for germination of alkali sacaton—light and temperature of 86°F. from 8 a.m. to 4 p.m.; darkness and 68°F. from 4 p.m. to 8 a.m.

Seeds put in the germinator at the start of the darkness-low temperature period germinated more rapidly than those started in light-high temperature. The effect appears to be mainly one of rapidity of germination, as the effect is not as obvious after the fourth day.

Mechanical scarification increases alkali sacaton germination

Experience has shown that fresh seeds of alkali sacaton germinate poorly, and that seeds 1 to 2 years old germinate only approximately 60 percent. Seeds from three lots, one aged 8 months, and two lots aged 20 months, were scarified mechanically by scratching the seed coats between emery cloths. Subsequent germination averaged about 93 percent.

Germinable seed content of the soils of the Rio Puerco watershed area

Why don't alkali sacaton plants become established on the barren flood plain sites of the Rio Puerco watershed in New Mexico? These flood plain sites are approximately 50 to 100 feet across, and are usually relatively close to a seed source, with one or more sides bordered by established stands.

Tests indicate there is a marked difference in the germinable seed content of the soils within as opposed to outside the stands. Surprisingly, there appear to be virtually no seeds in the soils of the barren sites. Also, the number of germinable seeds in the soil varies considerably from season to season; many more seedlings emerged from samples taken in November and June than in December or March. This would seem to be due to afterripening of the seeds disseminated the previous fall; however, the reason for the drop in germinable seed content of the soils collected in June and September is obscure. These samples were taken from soil sites adjacent to those collected in November, and, thus, it seems reasonable to assume that they should contain as many seeds. Either the sampling procedure is not adequate or some force is acting during the period from November through September which reduces the viability or simply eliminates the seeds in the soils.

Forest Economics, Utilization, and Marketing Research

Forest Economics

Treatments completed or underway on 6 of 18 small Beaver Creek watersheds

The Beaver Creek Pilot Watershed is a 275,000-acre outdoor laboratory in central Arizona that is being used to test and evaluate the economic and the multiple use effects of management practices designed to increase streamflow. The area includes 18 small watersheds where alternative treatments can be tested under controlled conditions. Six of the 18 are now in use.

Watershed 1, in the Utah juniper type, was cabled in 1963, followed by slash burning and seeding to grass. It continues to show no change in water or sediment yield, but herbage production has increased significantly.

On Watershed 6, in the alligator juniper type, all the trees were felled with saws in 1965 and left in place. So far, water yield changes are too small to be significant. Measurements and evaluations are continuing.

Watershed 12, in the ponderosa pine type, was clearcut in 1966 and the slash windrowed in a pattern designed to maximize snow trapping and retention, and to expedite runoff of surface water into the streams. Preliminary evaluation of the watershed's behavior during the wet summer of 1967 indicates large increases in streamflow, but also in sediment yield and erosion. Firm conclusions will be drawn only after several years of study.

The vegetation on Watershed 3, in the Utah juniper type, was desiccated in May 1967, in preparation for burning, but wet weather made it necessary to postpone the burning treatments for a year.

On Watershed 9, in the ponderosa pine type, a strip-cutting treatment was begun in the fall of 1967. The "cut" and "leave" strips are 60 feet and 120 feet wide, respectively, and are designed to provide for increased trapping and retention of snow, and for efficient transport of surface runoff into the stream channels.

Watershed 11, originally a ponderosa pine watershed that was clearcut and converted to grass several years ago, is now being grazed by cattle, to test the effects of herbage reduction on water yield. For the first few years, grazing use will be at the 50 percent level; then, if there is no indication of changes in water yield, the level of grazing will be increased, step by step to try to detect the level of herbage use at which a change in streamflow takes place.

Sediment inventory and prediction systems have been developed

One of the important resource changes that will result from treatments on the Beaver Creek Pilot Watersheds will be the yield of sediment. Measurements of sediment yields before and after treatment are a part of the regular inventories being carried out on all watersheds where drastic treatments are to be applied. The basic measurement system consists of a rock masonry streamflow impoundment that retains the coarse sediment particles, and a series of splitters that sample sediment suspended in the flow leaving the impoundment (fig. E-1). Data collected so far show that sediment yields vary greatly from year to year. For example, the heaviest yield from one untreated alligator juniper watershed was over seven times the low yield.

Figure E-1.--Typical installation of sediment basin and splitters especially designed to measure sediment yields on the Beaver Creek Pilot Watersheds.

In addition to this system of sediment inventory, special studies are underway that have provided equations for predicting sediment yield on the basis of such watershed characteristics as elevation, litter index, and stream discharge.

Snowpack affected by timber stocking

Timber stocking, elevation, and other variables were analyzed on a 425-acre ponderosa pine watershed to determine their effects on peak snow accumulation. First-year results suggest that it may be possible to increase snowpack for streamflow by reducing timber stocking.

More snow was measured under sparsely stocked than dense timber stands. Water equivalent of the snowpack increased from less than 1 to over 7 inches as timber stocking levels decreased from 250 to less than 25 square feet of basal area per acre.

Greater amounts of snow accumulated at higher than lower elevations, reflecting more precipitation and lower temperatures at higher elevations. Snow water equivalent increased uniformly from less than 2 to 6 inches as the elevation increased from 6,800 to 7,300 feet.

Almost all of the snowpack left the watershed as surface runoff. The mean water equivalent of the pack at the start of melt on March 4 was 3.36 inches; by March 20, only 0.05 inch remained. During the same period, 3.08 inches of runoff was measured at the gaging station. This represented 93 percent of the water depleted from the melting snowpack.

Watershed treatments will change the forest floor

The forest floor, consisting of dead organic plant matter, is being studied because of its effects on herbage production and hydrologic performance. It is one of the site characteristics most drastically altered by watershed management practices. Inventories of forest floor under ponderosa pine on Beaver Creek have shown the mean depth to be 1.3 inches (9.3 tons per acre).

Herbage production on forest sites decreases from over 700 to less than 50 pounds per acre as forest floor accumulations increase from zero depth to over 2.5 inches. The well-decomposed "H" layer and total depth account for more variation in herbage production than the unaltered litter "L" or partially decomposed "F" layers.

Maximum field water content of the forest floor is being studied also. This amount of precipitation, which can be caught and held by the forest floor, is not available for streamflow. Maximum field water content, based on average weight of the forest floor, is approximately one-tenth of an inch. About 85 percent of this is held by the H layer, 3 percent by the L layer, and 12 percent by the F layer.

Forest Products Utilization

Laminated decking from Black Hills ponderosa pine shows good strength

Most of the lumber cut from ponderosa pine in the Black Hills, Central Rocky Mountains, and the Southwest generally is in the lower common grades and has low market value. Laminated decking for roofs and floors shows promise as a higher valued use for this lumber. The laminated decking is made so that defects will have a minimum effect on either strength or appearance of the panels.

Forty decking panels involving various combinations of lumber grades from Black Hills ponderosa pine were tested for stiffness and bending strength (fig. U-1). Both stiffness and ultimate load-carrying capacity of panels made with faces of three common and cores of four common lumber were superior to 2-4-1 Douglas-fir plywood decking.

The tests were also designed to investigate the strains that develop around knots when panels are under various loads. Strain gages were placed on and near the knots on panel faces (fig. U-2). Strains and corresponding loads were plotted simultaneously while the panels were tested by static bending. Families of stress-strain curves for the test panels are being compared to determine whether some areas on or around knots are weaker or stronger than other areas.

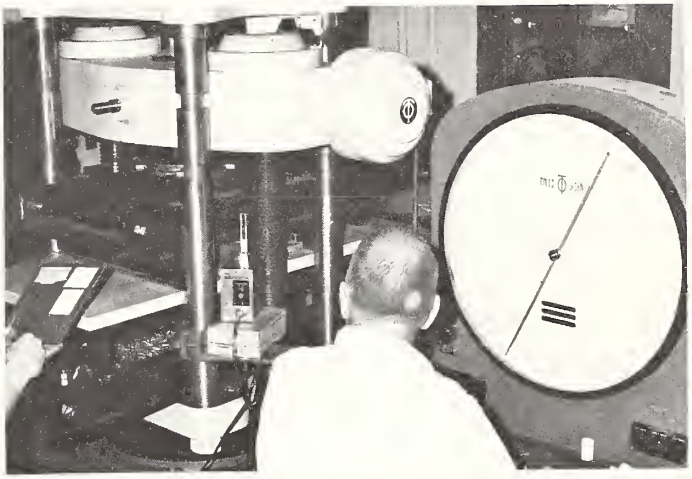


Figure U-1.--Testing of panel with quarter-point loading in static bending.

Small-diameter Black Hills ponderosa pine—a possible supplemental veneer log supply

A preliminary study of "blackjack" ponderosa pine in the Black Hills indicates that these trees may be a source of veneer for sheathing-grade plywood.

The limited study, made to develop preliminary leads for additional research, involved 10 logs, 12 feet in length, selected randomly from a sawmill log deck (fig. U-3). The logs varied from 8 to 15 inches in diameter at the top. Logs that obviously would not yield at least grade D veneer were omitted. On the basis of the Improved Ponderosa Pine Log Grades, two of the logs were grade 2; one, grade 3; and seven were grade 5.

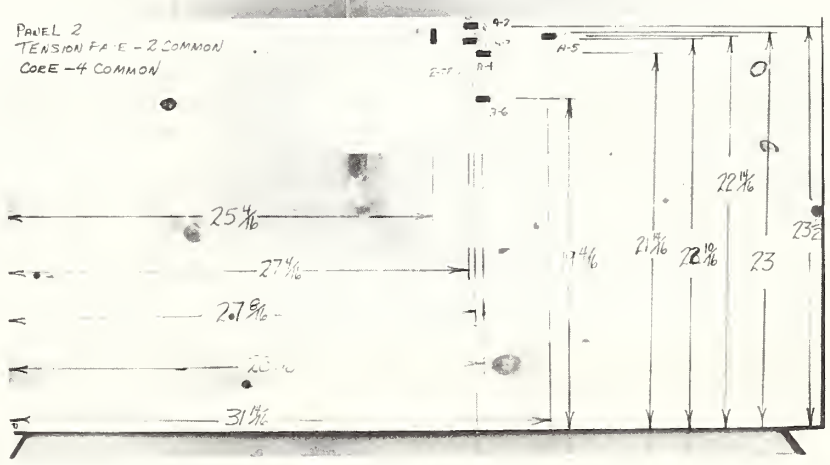


Figure U-2.--Location and size of knots in a typical test panel, and location of strain gages about a defect (top, center).

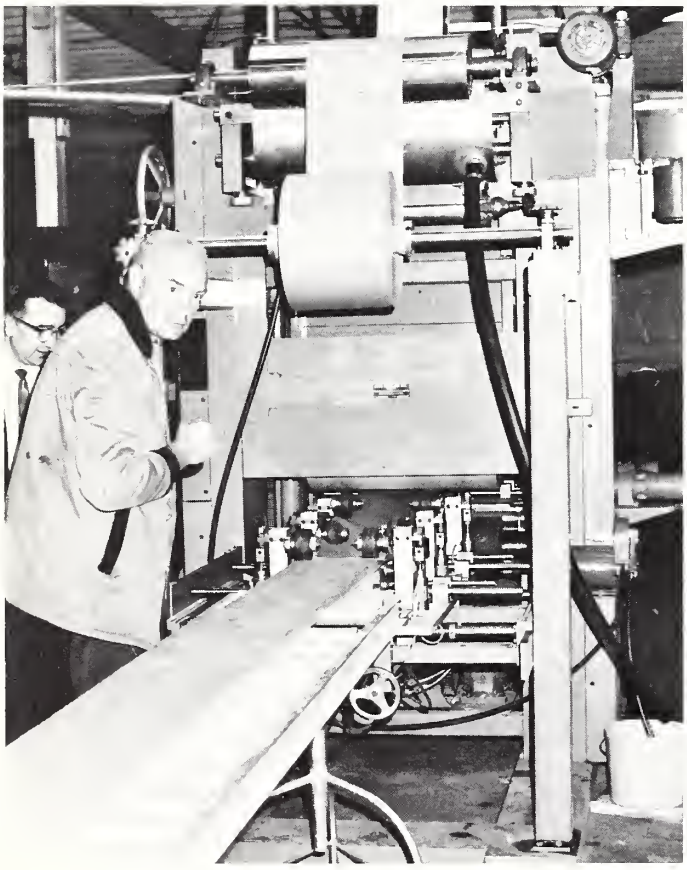
Figure U-3.--Black Hills ponderosa pine logs (blackjack) tested in veneer-plywood study.

The logs were peeled to a 6-inch core on 4-foot rotary lathes at the Forest Products Laboratory. The study was designed to provide for projecting the veneer and plywood yields on the basis of both 8-foot and 4-foot bolts. Average percent veneer yields were:

	Grade C	Grade D
4-foot bolts	52.4	47.6
8-foot bolts	25.4	74.6

The yield of 3/8-inch plywood, in square feet of plywood per board foot log scale, was:

4-foot bolts	2.9
8-foot bolts	2.6



Roll laminator procured for lumber overlay study

A roll laminating machine designed to apply a continuous cellulosic or plastic overlay to the surface of lumber (fig. U-4) has been obtained for use in a study to determine the feasibility of upgrading lumber. The major objective of overlaying lumber is to broaden and improve the marketability of low-grade ponderosa pine by improving its appearance and paintability.

The study is partly financed by the Economic Development Administration. Other coopera-

Figure U-4.--Roll laminator designed to apply overlay film to surface of lumber.

tors are the Duke City Lumber Company of Albuquerque, New Mexico; the Northern Rio Grande Conservation and Development Project; and the New Mexico State Planning Board.

Final moisture content of laminated beams is 6 to 8 percent

Laminated beams are important structural members in many modern buildings. Information on variations in moisture content of beams in use throughout the nation will help the wood laminating industry to make beams at the best moisture content. The Rocky Mountain Station is participating in a study designed to develop this information. Moisture measurements on beams in 25 buildings in South Dakota, Colorado, New Mexico, and Arizona are to be taken four times a year over a 5-year period. The measurements are made with a resistance-type moisture meter attached to specially designed wooden probes sealed inside each beam. Moisture conditions are sampled at the compression, neutral, and tension axis, as well as at points near metal connectors and end sections (fig. U-5). Thermocouples also are embedded with some of the probes to provide data on temperatures related to moisture content.

Results after the first year indicate that the moisture content of beams in use generally ranges from 6 to 8 percent. Higher moisture contents were sometimes found in the beams on the exterior of buildings after periods of precipitation or high humidity.

Cutover ponderosa pine has potential for variety of primary products

Cutover ponderosa pine stands form a major part of the forest resource in the Southwest. Optimum use of the resource for new products and in diversified operations requires better knowledge of the product potential of this timber. A recent study documented the quantity and quality of potential primary products

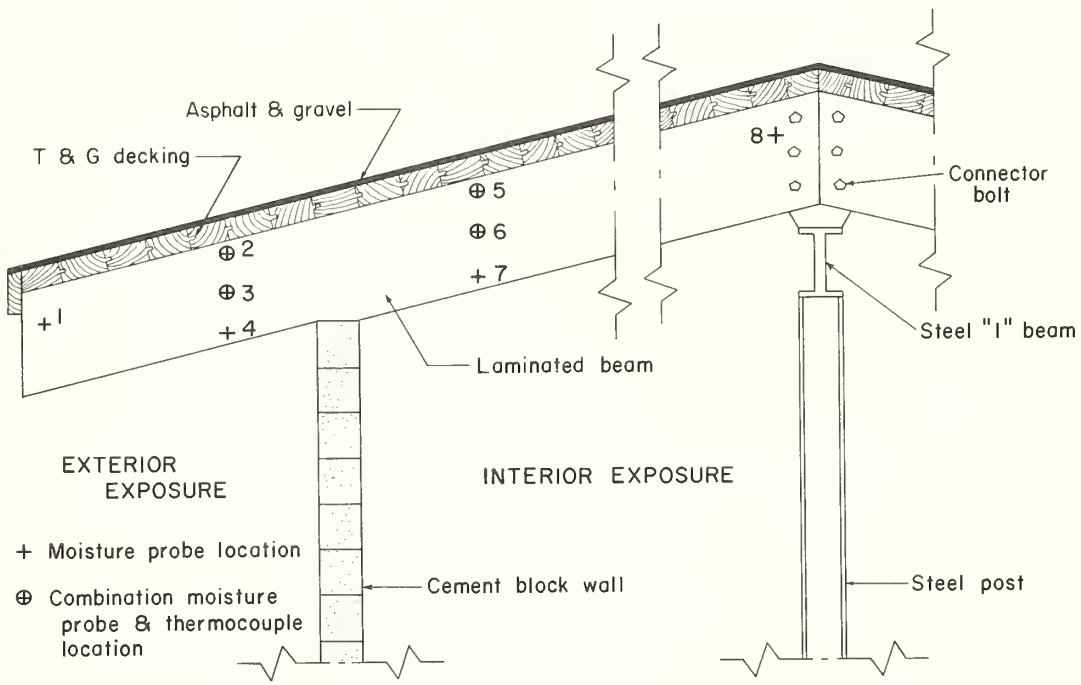


Figure U-5.--Outdoor and indoor locations of moisture probes and thermocouples.

removed in a clearcut logging operation in previously cutover ponderosa pine. Data for the study area are broadly indicative of product potential in much of the cutover pine type in the Southwest.

As timber on the area was cut, a large proportion of the material was scaled and graded, if suitable, for a variety of products including saw logs, veneer logs, stud logs, pulpwood, and commercial poles. The percentage of the stand volume meeting specifications for each grade of the three log products was:

	Saw	Veneer	Stud
Grade:			
1	0	0.4	0.2
2	.2	13.6	.5
3	6.6	27.9	17.6
5	93.2	--	--
Total	100.0	41.9	18.3

The five-grade improved system was used for saw logs; a tentative three-grade classification system for veneer and stud logs.

Fifteen percent of the trees larger than 10 inches in diameter were suitable for commercial poles. The pole potential on the study area amounted to 2.1 poles per acre.

Top material left as logging residue was scaled for pulpwood when suitable (that is, relatively straight, 5-foot minimum bolt length, and 4-inch minimum bolt diameter). The scaled material totaled 20 cubic feet per acre, or approximately 10 cubic feet (1/8 cord) per thousand board feet of material logged from the area.

Forest Products Marketing

Arizona's lumber industry changes

In Arizona, as in the rest of the Rocky Mountain area, the lumber industry has been changing. Some mills have quit business; others have grown bigger and often more efficient. In 1956 there were 66 mills in Arizona. By 1965 there were only 25. Average annual output per mill increased fourfold, however, and total production in the State grew from about 241 million to 365 million board feet.

Most of Arizona's lumber is marketed in the Southwest

In 1965, one-fourth of Arizona's lumber stayed in the State, while three-fourths was shipped to other markets. Half the lumber shipped out-of-State went to the nearby southwestern States of Texas, New Mexico, California, and Oklahoma (fig. M-1). One-fourth went to the Central and Lake States areas, including Illinois, Ohio, Michigan, and Missouri.

Between 1959 and 1965, there was a shift in markets with more Arizona lumber going to Texas, Oklahoma, Arkansas, and Louisiana, and less going to markets in the Central States.

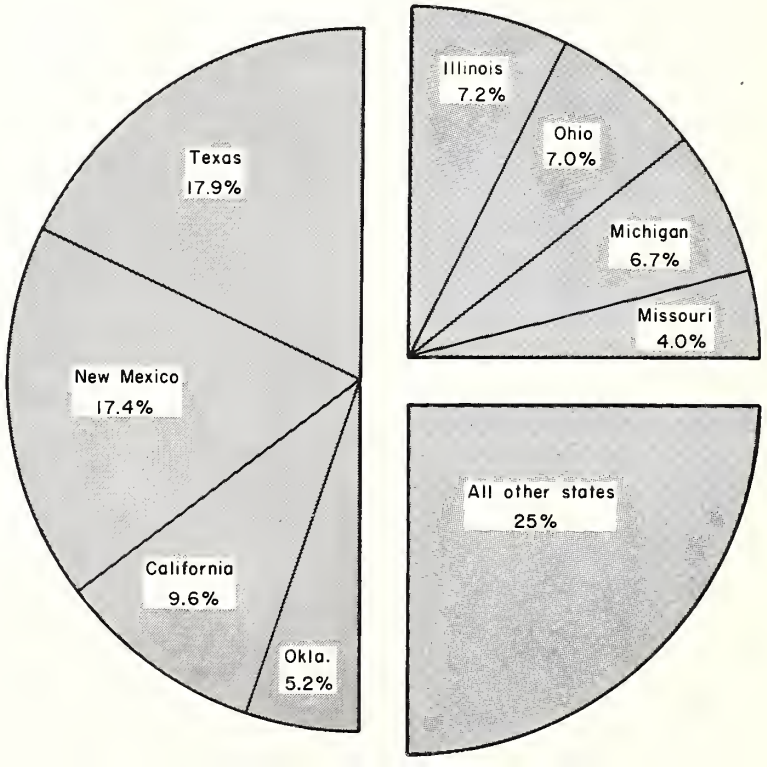


Figure M-1.--Most important out-of-State markets for Arizona lumber. Proportions of total shipments from Arizona in 1965.

Quality of resource and product are key market problems for Arizona lumber mills

Most of Arizona's lumber (82-89 percent) is cut from ponderosa pine. The kinds and grades of lumber that can be cut are strictly limited by the quality of the log. In the Southwest, ponderosa pine tends to have many knots and other growth characteristics that result in low-quality saw logs.

Three-fourths of all lumber sold by Arizona mills in 1965 was in the lower common grades of both boards and dimension lumber. Only about one-fifth was shop lumber, and only 5 to 7 percent was marketed as select grades of lumber. The lower grades have lower market values, and these values have been declining as panel-type wood products and other materials have replaced the lower common grades of lumber for some uses.

In recent years, raw material that formerly yielded No. 5 Common boards has been diverted to chips for pulp and paper manufacture. Mill residues, formerly wasted, also are going to the pulpmill. This development has improved the lumber industry's economic health. Many of Arizona's larger mills have installed chippers to take advantage of this opportunity.

Production shifts to meet market demand

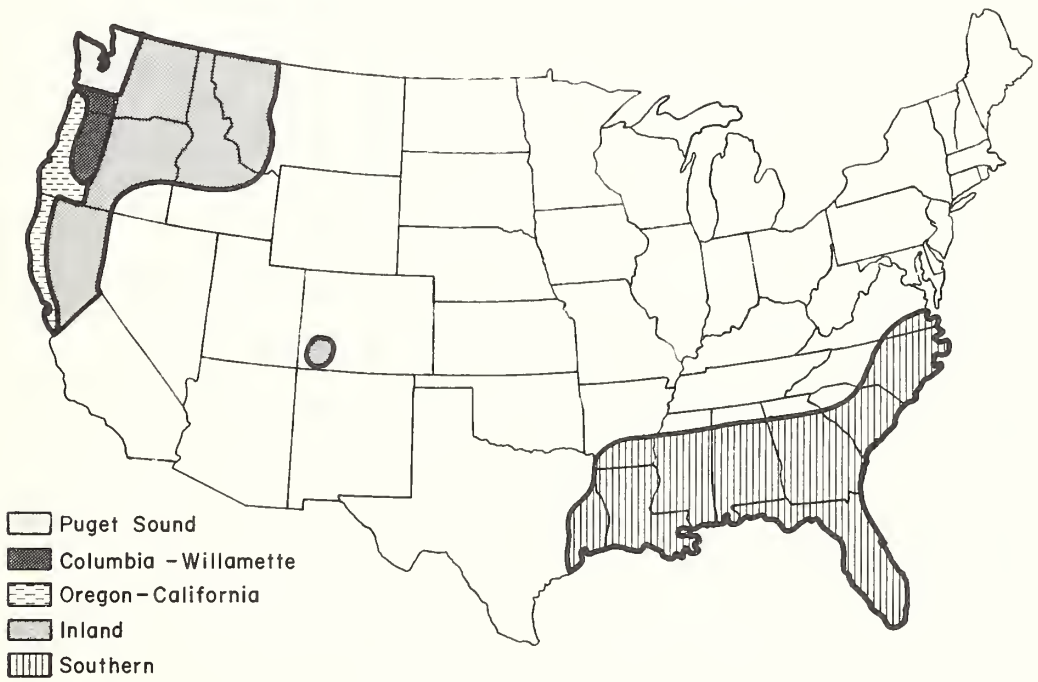
Changes in building methods, uses of lumber, and consumer tastes have caused a change in the mixtures of products produced by Arizona mills. The biggest change has been a shift to production of more dimension lumber and fewer boards.

Most softwood plywood is made in the West, used in the East

What kinds of softwood plywood are made in the U. S.? How much? Where is it manufactured? Where does it go? Softwood plywood industry data for 1965 have been analyzed to answer these questions.

In 1965, over 86 percent of the 12,446 million square feet of softwood plywood was produced in the three westernmost Producing Regions (fig. M-2). Although the Southern Producing Region produced only about 3 percent of the nation's total, this is notable because the first Southern pine plywood mills had opened only 2 years earlier.

Figure M-2.--Five plywood producing regions in the United States.



About 71 percent of all the softwood plywood produced was of the interior type. Only 3 percent of the Southern pine production was of the exterior type, but plants in the Puget Sound Region produced interior and exterior types in about equal amounts.

The Northeast Market Area (fig. M-3) received 20 percent of all the plywood produced, and the Lake States received 16 percent. The West Coast Market Area also received 20 percent of the shipments. The other market areas received 4 to 9 percent each.

Plywood plants in the Columbia-Willamette and Oregon-California Producing Regions supplied 60 percent of the demand in all market areas. The newly established Southern pine plywood industry marketed over 76 percent of its output in the four Gulf and South Atlantic Coast Market Areas.

Figure M-3.--Ten plywood market areas in the United States (map with 50 major trading area boundaries copyrighted by Rand McNally and Company, R. L. 68-S-19.)

Timber Management and Forest Protection Research

Timber Management

Site index curves developed for Engelmann spruce

Height-over-age curves have been prepared for estimating the productivity of even-aged Engelmann spruce stands in the central Rocky Mountains. Site index is expressed as the average height of dominant trees at breast height, age 100 years (fig. T-1). Since Engelmann spruce is tolerant of crowding, the height growth of dominant trees is unaffected by stand density.

Physiographic site equation developed for aspen

Site index of aspen was found to be related to habitat expressed as a moisture regime value and a temperature regime value in Colorado and northern New Mexico. Nutrient levels did not seem to limit height growth within the broad range sampled.

The moisture regime value incorporated regression estimates of monthly precipitation and temperature; theoretical direct beam insolation based on slope, aspect, and latitude; a simple expression of topographic concavity or convexity; and the water-holding capacity of the soil based on soil depth, texture, and stone content. The temperature regime value incorporated the estimated length and warmth of the vegetative season. The equation estimates site index with a standard error of 11.5 feet in a sampled site index range of 48 feet. Further analyses may improve accuracy.

On any given plot, however, the sample trees apparently belonged to a single clone, and different clones in closely similar nearby habitats sometimes had very different growth rates.

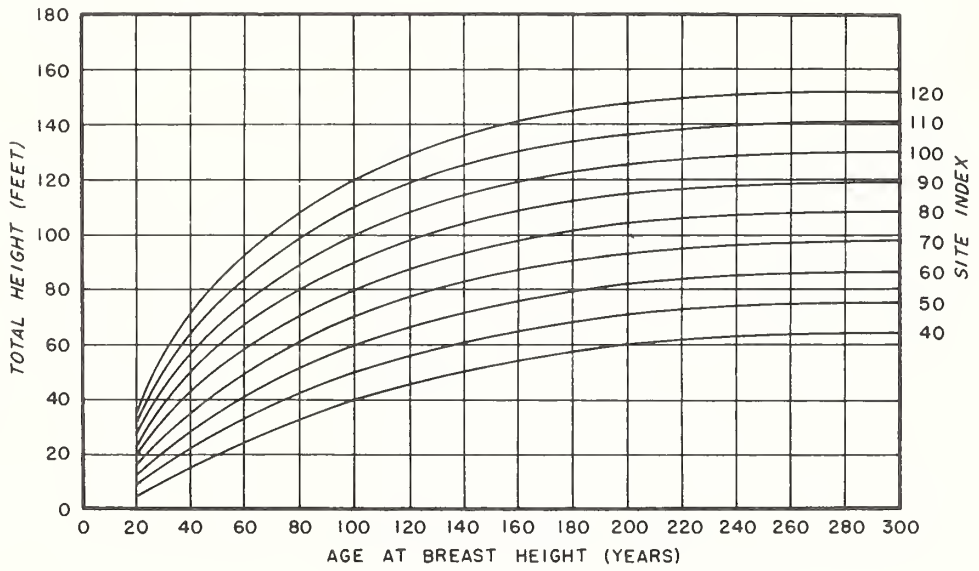


Figure T-1.--Site index curves for even-aged Engelmann spruce.

Habitat variation is consequently confounded with substantial interclonal genetic variation. This, along with the complexity of environmental variation, limits the accuracy obtainable.

Windfall after clearcutting on Fool Creek in Colorado

Nearly 3,000 trees were windthrown in 10 years along the margins of clearcut strips 1, 2, 3 and 6 chains wide on the Fool Creek drainage of the Fraser Experimental Forest (fig. T-2). Although windthrow along the boundaries of clearcut units cannot be eliminated entirely, the results of this study suggest the following ways that wind damage can be reduced in similar situations.

1. Stormwinds that caused most of the blowdown on Fool Creek came from the west, southwest, and south (fig. T-3). Cutting units should therefore be laid out so that cutting boundaries receive maximum protection from winds from those directions.
2. The downwind (N, NE, E, and SE) edges of cut strips suffered the most damage because they were subjected to the greatest force of stormwinds. Reduction of windfall should be a major consideration in locating those cutting boundaries. A normal amount of care in locating upwind (NW, W, SW, and S) boundaries should be sufficient to keep windfall to a minimum.
3. The relationship of windthrow to topographic position on the slope suggests that under no circumstances should cutting boundaries be located on ridgetops (fig. T-4).

Figure T-2.--Aerial view of Fool Creek showing the cutting pattern and road network.

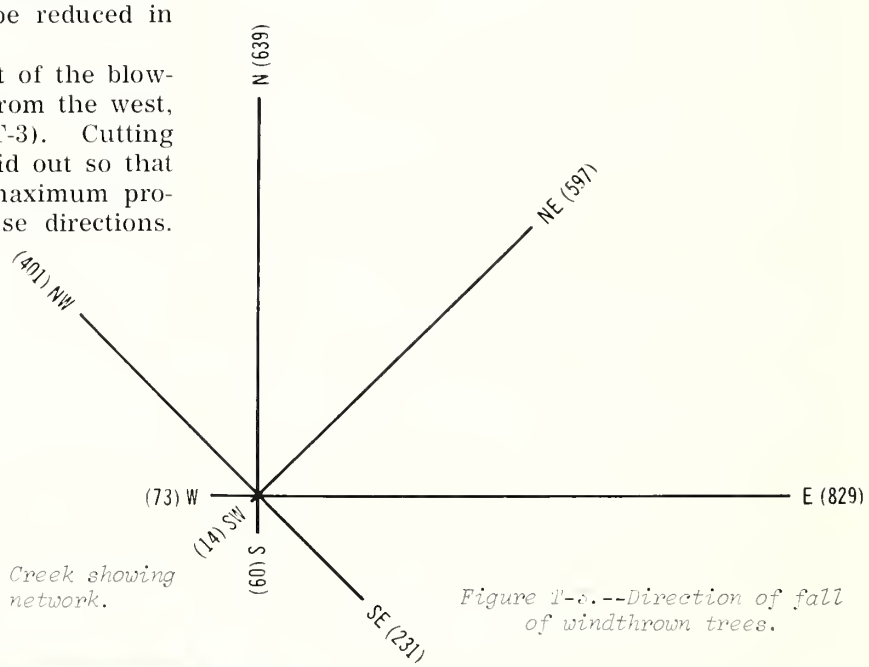


Figure T-3.--Direction of fall of windthrown trees.

4. Do not locate cutting boundaries on poorly drained or shallow soils. Trees grown in those situations are shallow rooted and susceptible to blowdown.
5. Although windfall was not directly related to size of opening, larger units have less perimeter exposed per unit of area cut, and larger units permit more flexibility in locating boundary lines.
6. Windfall on Fool Creek and on other areas studied has been heaviest the first few years after cutting. Salvage and insect control operations should be timed to take advantage of this situation.

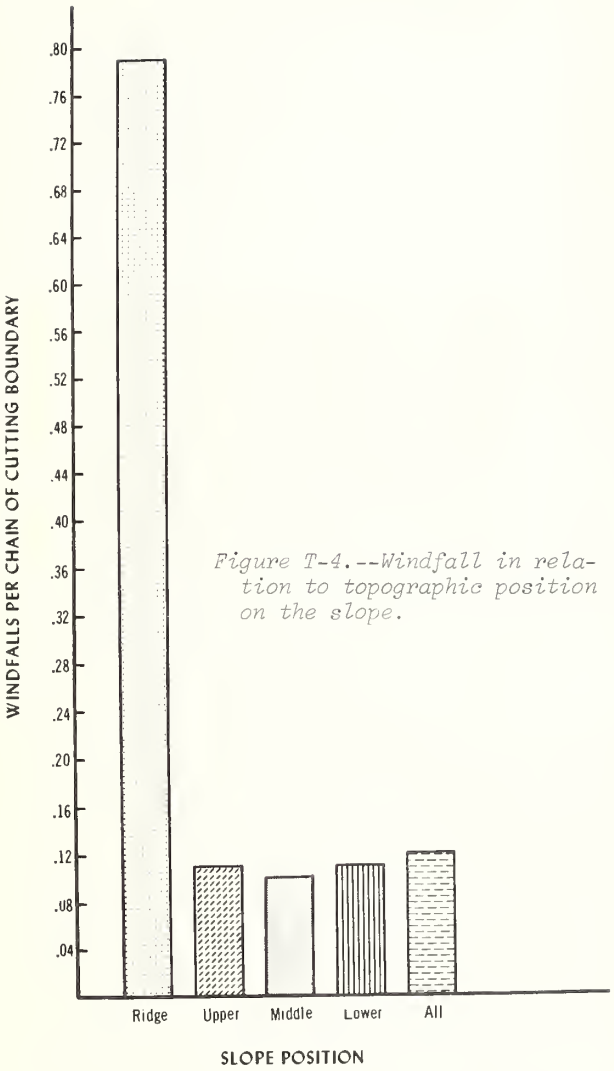


Figure T-4.--Windfall in relation to topographic position on the slope.

Dehydration not responsible for winter mortality of spruce seedlings

Seedlings of Engelmann spruce that are planted in the open at high elevations usually survive well through the growing season, but do poorly overwinter. If shaded through the summer, they survive winters well. The foliage of open-grown seedlings almost invariably turns yellowish for the first few years; foliage of shaded seedlings remains a healthy blue green.

As shade affects both light and moisture, the influence of water stress on spruce seedlings was tested. The needles did not turn yellow in response to water stress. They faded gradually to a light green until the needles dropped. Water deficits of field-planted seedlings did not approach the lethal point during the study. Furthermore, no difference in water deficits was found between shaded and unshaded spruce, whether the measurements were made at sunrise or midafternoon.

It was therefore concluded that water stress alone was not responsible for the high winter mortality of spruce seedlings. Other findings follow:

1. Potted seedlings survived a foliage water deficit of up to 58 percent when computed by the following formula:

$$W = \frac{S - F}{S - O} \times 100$$

where
W = water deficit percent
S = saturated weight
F = fresh weight
O = ovendry weight

2. Photosynthesis apparently ceased when water deficit reached 16 to 18 percent (fig. T-5).
3. No seedlings recovered when rewatered if drought stress had progressed so far that new needles had started to fall. Seedlings started to shed old needles when the water deficit reached 53 percent and new needles at about 61 percent.

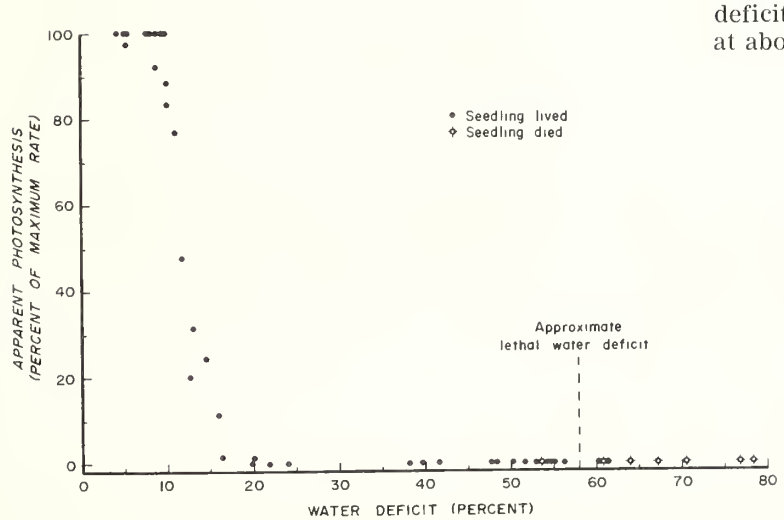


Figure T-5.--Relationship of apparent photosynthesis to water deficit and viability of droughted Engelmann spruce seedlings.

Gophers more damaging than cattle to pine plantation

According to first-year results of some ponderosa pine plantings on two watersheds in Arizona, pocket gophers caused the greatest loss of seedlings; losses to gophers were greater on the ungrazed watershed than on the grazed.

The grazed and ungrazed watersheds had similar soils, vegetative and tree covers, and site indexes for ponderosa pine. Plantings on each watershed were given three levels of protection from animals: (1) No protection, (2) protection from large animals (fig. T-6), and (3) surface protection from all animals. Vegetation was removed from all plots before planting. The cattle used an estimated 80 percent of the herbage on the grazed watershed and browsed 11 percent of the planted trees.

Mortality was only 19 percent on the grazed watershed at the end of the first season compared with 43 percent on the ungrazed. The difference was due mostly to gophers. Gophers killed 28 percent of the trees that were planted on the ungrazed watershed, but less than 9 percent on the grazed. Furthermore, they killed more trees on both watersheds on the plots that were protected from surface animals than on plots that were unprotected.

Drought was the second most important killer of planted seedlings.

Figure T-6.--Wire cone placed over plot to protect it from large mammals.

Figure T-7.--Strips of sudangrass provide year-round protection to newly planted ponderosa pines.

Herbaceous windbarriers aid establishment of single-row pine shelterbelt

Narrow strips of sudangrass planted on each side of a row of ponderosa pine in north-central North Dakota improved initial survival from 68 to 82 percent, and doubled height growth from 0.62 to 1.23 feet over a 4-year period (fig. T-7). Grass was planted the summer prior to tree planting, and again the summer following planting. The sudangrass barriers trapped snow to increase soil moisture, shielded trees from drying winds during the critical period immediately after planting, and protected them from winter desiccation by increasing snow cover and reducing exposure to wind.

Decadent shelterbelts rejuvenated by renewed cultivation

Tree plantings in the northern Plains are commonly invaded by sod-forming grasses that compete with, and reduce vigor of, the trees. Shelterbelts have resumed vigorous growth following renewed cultivation (fig. T-8).

Figure T-8.--Shelterbelt in North Dakota. All sod has been removed annually for 5 years from segment to man's left, but has not been disturbed in segment to man's right.

Different amounts of sod were removed from four 12- to 15-year-old shelterbelts, two on sandy soils and two on heavier soils (fig. T-9). Growth was as great in plots where a narrow strip of sod was left within rows (B treatment) as in plots where all sod was removed (A treatment). American and Siberian elms, green ash, and boxelder responded especially well.

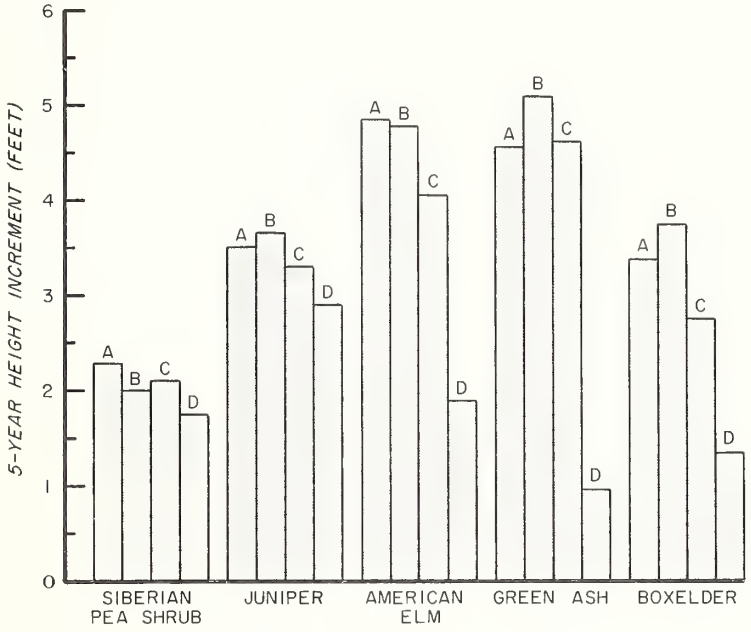


Figure T-9.--Height growth of a 15-year-old shelterbelt on medium-textured soil during a 5-year period following sod removal by cultivation. Treatments used were:

A. All sod removed.
B. Sod removed from between rows, left within rows.
C. One-half of sod removed.
D. No sod removed (control).

Forest Fire

Energy output of fire in chaparral measured

Reflective panels around small test fires apparently reflect enough heat back into the fire area to simulate large fires (fig. F-1). Chaparral fires burn briefly but hot. In the mid-fall test burn illustrated (fig. F-2), flames lasted only 2 minutes but flame temperature climbed above 1,700°F. The fire released a total of more than 90,000 calories of heat into one heat sink 7½ inches in diameter in a period of 7 minutes.

Approximately 200 test burns are to be made under a wide variety of burning conditions.

Figure F-1.--Small bodies of chaparral apparently burn as intensely as large fires when "fenced in" with reflective panels. Well-instrumented small fires are therefore efficient data producers.

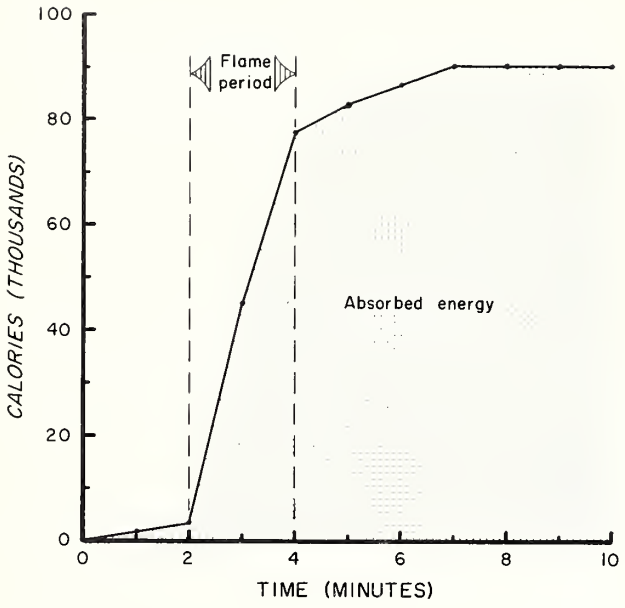


Figure F-2.--Burning chaparral releases lots of heat energy rapidly as shown by the energy absorbed by one 7-1/2-inch-diameter heat sink.

Flammability of Arizona chaparral may change with salts content

The level of inorganic salts of potassium and phosphorus in living chaparral leaves changes. Because potassium inhibits flaming combustion and phosphorus inhibits glowing combustion, the changes may influence flammability.

The concentration of phosphorus and potassium salts in shrub live oak and manzanita leaves as much as doubled in only 30 days in the fall of 1967. The increase in phosphorus was similar for both natural plants and plants sprayed with a phytocide. Potassium increased more in sprayed plants than in natural plants. The concentration of salts was lower in manzanita than in shrub live oak. This may be one reason why manzanita is more flammable than oak.

Precipitation and time of growth influence moisture and flammability of shrub live oak

Shrub live oak, in common with other chaparral species, typically makes a flush of growth in April and May. Moisture content of the foliage rises sharply at time of growth, and flammability drops (fig. F-3).

The 2 to 3 inches of precipitation that fell at the Prescribed Fire Experimental Area near Cherry, Arizona, during the winter of 1966-67 was too little to sustain a flush of growth in the spring of 1967. Leaf moisture content remained low, and chaparral flammable, through most of the summer. Leaf moisture increased moderately in May, June, and July when additional soil moisture was available. It took more than 4 inches of summer rain, however, before the oak finally made its annual flush of growth, in August. The flush was accompanied by the usual sharp rise in foliage moisture, which carried over into fall and interfered with early fall burning.

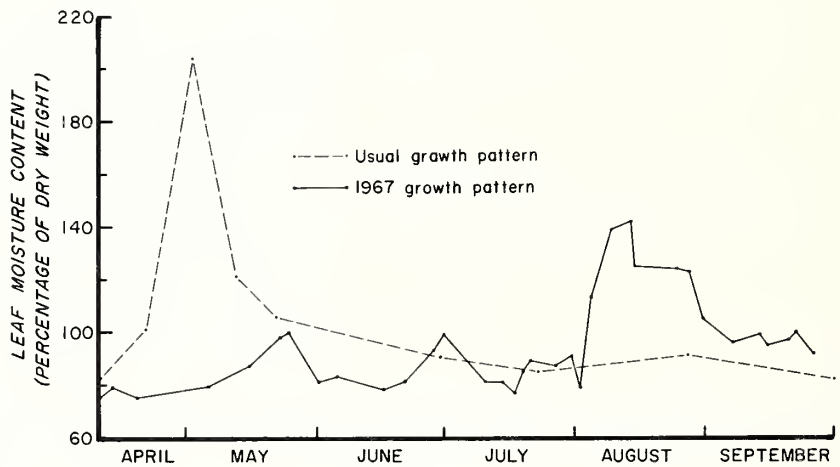


Figure F-3.--Shrub live oak in Arizona during 1967 grew mostly in August, instead of April and May, the usual growth period. Foliage moisture peaks indicate growth periods.

Figure I-1.--Ponderosa pine seedling protected by dimethoate spray made good terminal growth (left). The terminal bud of an unprotected seedling (right) was killed by Rhyacionia neomexicana.

Forest Insects

Tip moth impeding growth of ponderosa pine

Infestations of the southwestern pine tip moth Rhyacionia neomexicana are seriously impeding the growth and development of both plantations and natural reproduction of ponderosa pine in Arizona. Application of dimethoate at concentrations as low as 0.25 pound per 100 gallons of water permitted a significant increase in terminal growth (fig. I-1).

This insect has one generation per year. The adults emerge in the spring and lay their eggs on the inner surface of the previous year's needles just above the needle sheath. After hatching during the first week of June, the larvae bore into the buds and current year's growth (fig. I-2). At maturity, the larvae migrate downward and pupate in cases attached to the base of the tree at the ground line. The larva bore a small hole into the cambium, causing a flow of resin that is utilized in the construction of the pupal case (fig. I-3).

Figure I-2.--Larva of R. neomexicana boring into the growing shoot on a ponderosa pine seedling. Up to 30 larvae have been observed to infest a single shoot.

Figure I-3.--Removing soil from base of ponderosa seedling exposes pupae of R. neomexicana.

Infestation trend of western budworm related to number surviving through bud-mining stage

Periodically the western budworm (Choristoneura occidentalis Freeman) becomes epidemic on thousands of acres of Douglas-fir and white fir. Epidemics may persist for several years and cause extensive damage. Causes of the rise and fall of outbreaks have not been clear. In the past 4 years, infestation trend was found to be downward when mortality was heavy between the egg stage in August and the one-fourth-grown larval stage the following May. The average mortality of declining infestations during this period was 72 percent, and of increasing infestations 17 percent. The causes of this heavy mortality are yet to be determined. Biological control factors, including insect parasites and predators, were not as important as expected in determining trends of infestations.

Attack pattern of Black Hills beetle

The progress of a typical infestation of the Black Hills beetle brought to preselected ponderosa pine trees by an attractant source (a short pine bolt infested with female beetles and hung on a healthy tree) is shown graphically in fig. I-4. Beetles generally infested the attractant tree first. As time passed, trees farther and farther in all directions from the attractant became infested. Trees below 4 inches in diameter at breast height were not infested, while trees with a 12-inch diameter were most often attacked and killed.

We have had considerable success during the past few years in establishing infested groups of trees adjacent to trees attacked the previous year. The technique can be used to hold the beetles in one location for study and control purposes.

Nematodes vs. Hymenopterous parasites for controlling bark beetles

Impact of the parasitic nematodes Contortylenchus and Parasitylenchus and the hymenopterous parasite Tomicobia tibialis on the bark beetle, Ips pilifrons, were compared. Female beetles infested with Contortylenchus produced an average of 4.7 individuals, compared with 40.6 per noninfested female. Females infested with Parasitylenchus were affected less; they produced 22.5 individuals. Female beetles parasitized by Tomicobia tibialis, produced an average of 7.3 individuals. Nematodes are parasites of the immature forms of the beetles, and develop as the beetles develop; T. tibialis parasitizes only the adult stage.

All beetles infested by the insect parasite ultimately died, but only after brood production. Nematode parasites do not commonly kill their hosts.

Parasitized males are able to fertilize their mates in a normal manner. Females mated to parasitized males produce normal numbers of offspring. Male beetles infested with Tomicobia tibialis, however, die after mating.

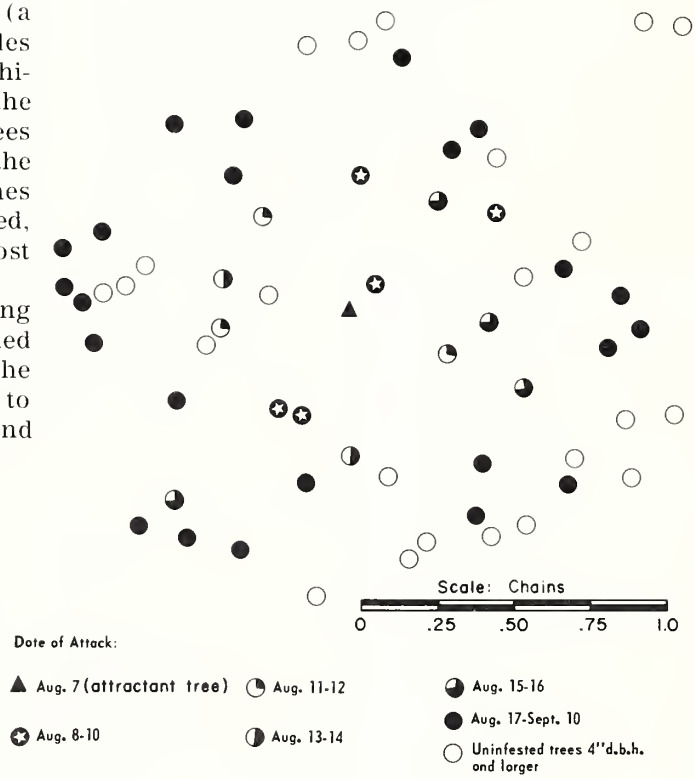


Figure I-4.--Development of a group attack of the Black Hills beetle in a ponderosa pine stand induced by an attractant tree (triangle in center of graph).

An asilid fly preys upon Black Hills beetle

As asilid fly (Laphria gilva (L.)) was found to be an active and abundant predator of the Black Hills beetle (Dendroctonus ponderosae Hopk.) in flight. The asilid perches head downward on the bole of a ponderosa pine infested with the beetle. Upon sighting a beetle, the asilid darts from the tree and captures it. Within seconds, it returns to almost its exact prior position with the beetle transfixed on the proboscis (fig. I-5).

While this predator alone is not a major natural control factor of the Black Hills beetle, it plus others being studied have an important total regulating effect on the abundance of this serious tree-killing bark beetle.

Figure I-5.--An asilid fly, perched head downward, feeding on a captured Black Hills beetle.

Immature stages of parasites and predators of the Engelmann spruce beetle identified

The immature stages of known insect parasites and predators of the Engelmann spruce beetle (Dendroctonus obesus Mann.) were identified and described. A field identification key will be developed from this information. The key will be used to evaluate the importance of insect parasites and predators in regulating the occurrence of outbreaks of tree-killing bark beetles.

One of the more important parasites is the larva of a small wasp, Coeloides dendroctoni Cush. The larva pierces the body wall of the beetle larva and feeds on the body contents (fig. I-6). Six species of parasites and predators were common in the study areas.

Thirteen new nematodes found in bark beetles

During the year, 13 new kinds of nematodes were recovered from the body cavities of bark beetles from the Rocky Mountain region. Bark beetles involved include Pityogenes carinalatus, Pityophthorus sp., Ips pini, Pseudohylesinus sp., Hylastes sp., Hylurgops sp., Ips pilifrons, and Ips sulcifrons. Effects of the nematodes on the bark beetles have not been determined yet.

Figure I-6.--Larva of a wasp, Coeloides dendroctoni Cush., feeding on a larva of the Engelmann spruce beetle.

Figure D-1.--Ceratocystis populina Hinds & Davidson. Mature perithecium base ornamented with short-conical spines. (X200).

New species of Ceratocystis found associated with aspen cankers

Two species of Ceratocystis, C. fimbriata Ell. & Halst. and C. tremula-aurea Davidson & Hinds, have been associated with aspen cankers in Colorado. An additional species of Ceratocystis was recently isolated from a canker. While the isolate produced perithecia and conidia in culture, it produced water of gutation instead of ascospores. It was then grown on several synthetic media with vitamin supplements, on several natural substrates, and in light and darkness, at temperatures from 3° to 30°C. None of these conditions led to the production of ascospores. The following spring the isolate was inoculated into axe wounds in a freshly felled aspen in the woods. Within 5 weeks the exposed wood of the wounds was blue stained and covered with mature perithecia exuding gelatinous masses of bean-shaped ascospores.

The fungus has been named C. populina Hinds & Davidson. It is similar to C. moniliformis (Hedgc.) C. Moreau in that the perithecia are ornamented with short, conical spines (fig. D-1), but the imperfect stage is quite different. Masses of racket-shaped hyphal cells near the bases of mature perithecia are characteristic of the species (fig. D-2).

Early observations of inoculations with C. fimbriata indicate that it is capable of forming trunk cankers, whereas C. tremula-aurea is not. One-year observations of inoculations with C. populina indicate that it is pathogenic, but it will take several years to determine its canker-producing potential.

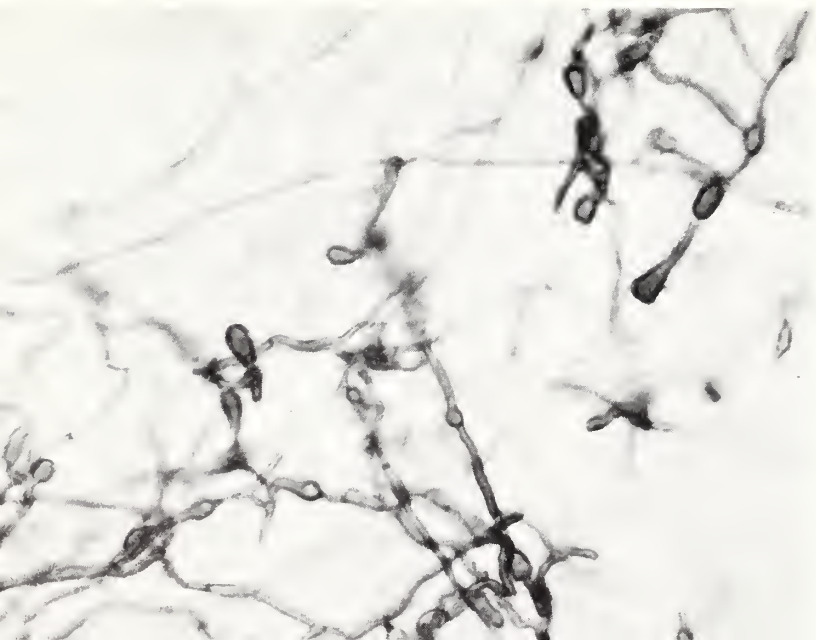


Figure D-2.--Ceratocystis populina Hinds & Davidson. Brown, racket-shaped hyphal cells found beneath mature perithecia (X750).

Figure D-3.--Red rot of ponderosa pine which typically enters the tree through dead branches.

Brown rots rival red rot in Black Hills ponderosa pine

Red rot, caused by Polyporus anceps, has been recognized for many years as the major defect of merchantable ponderosa pine sawtimber in the Black Hills of South Dakota (fig. D-3). Red rot volumes increase with age of the trees. Brown rots (fig. D-4) were found from a recent study to cause losses that are nearly as great as shown in the following tabulation:

Defect:	Incidence (Percent)	Proportion of gross volume (Percent)
Red rot	68	8.6
Brown rots	36	7.3
Other (mechanical)	--	3.3
Total		19.2

Since brown rots are most prevalent in overmature trees, they probably will be of little consequence in second-growth sawtimber.

Figure D-4.--Brown rot associated with partially healed wound at top end of a 16-foot butt log.

Nematodes restrict development of mycorrhizal fungi

It appears that myceliophagus nematodes may have a limiting effect on beneficial root mycorrhizae in central New Mexico.

Forty known or suspected mycorrhizal fungi were grown on agar. Two hundred nematodes (an undescribed species of Aphelenchoides) were added to each culture. After 40 days the mean linear growth of the nematode-treated fungi was reduced to only 22 to 50 percent of controls for 8 fungi, 51 to 73 percent for 13 fungi, and 75 to 100 percent for the remaining 19. Eleven of the fungi failed to grow when transferred to fresh agar, and the viability of 13 others was reduced. The nematodes had no apparent effect on the viability of the other 16 fungi. The nematodes reproduced readily on four fungi, where their populations increased 1,300- to 2,400-fold over the number initially added. Nematodes failed to maintain themselves on three other fungi or in cultures that contained the medium alone.

Damage to Russian-olive in the Great Plains due to the fungus Botryodiplodia theobromae Pat.

Widespread damage to Russian-olive in Great Plains shelterbelts is due to a fungus identified as Botryodiplodia theobromae Pat. The disease is accompanied by canker formation and gradual killing of branches and ultimately the whole tree. Disease development in inoculated Russian-olives was typical of disease development in naturally infected trees.

Oak wilt found in four more Nebraska counties

Oak wilt (Ceratocystis fagacearum) was found for the first time in four more Nebraska counties—Sarpy, Cass, Otoe, Nemaha—during an aerial and ground survey made in eastern Nebraska in 1966. Previously, oak wilt had been found in only two Nebraska counties—Richardson in 1950 and Douglas in 1964.

Cercospora blight of redcedars controlled by Bordeaux mixture

Blight caused by Cercospora sequoiae E. and E. is killing eastern redcedar and Rocky Mountain juniper in Nebraska shelterbelts. Good control of this fungus was obtained with three to five applications of Bordeaux mixture (8-8-100) applied at 3-week intervals beginning in early May.

Diplodia tip blight damaging pines in the central Great Plains

Tip blight caused by Diplodia pinea (Desm.) Kickx is causing serious damage to Austrian, Scots, and ponderosa pines in Nebraska and Kansas, especially in plantings over 30 years old. Infection was reduced about 50 percent with Bordeaux mixture (8-8-100) applied three times at 3-week intervals beginning in mid-May; infection incidence was similar whether or not infected tissue was pruned. Nonsprayed trees, whether pruned or not, had a high level of infection.

Publications

Aldon, Earl F., and Garcia, George.

Summer deferred grazing can improve deteriorated semidesert ranges. U. S. Forest Serv. Res. Note RM-95, 3 pp.

Research in west-central New Mexico showed alkali sacaton on flood plains offers management its best chance for increasing productivity of semidesert lands. It is highly palatable, and can produce much herbage on a relatively small area. Under summer-deferred grazing, production of alkali sacaton has been gradually increasing in spite of variable precipitation.

Alexander, Robert R.

Site indexes for Engelmann spruce in the central Rocky Mountains. U.S. Forest Serv. Res. Paper RM-32, 7 pp., illus.

Figures and tables are presented for estimating site indexes for Engelmann spruce from data collected in Colorado and Wyoming. Site index is expressed as the average height of dominant spruce trees in spruce-fir stands at breast height age 100 years.

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Windfall after clearcutting on Fool Creek—Fraser Experimental Forest, Colorado. U. S. Forest Serv. Res. Note RM-92, 11 pp., illus.

Windfall was studied for 10 years along the perimeters of 183 alternate clearcut strips in spruce-fir and lodgepole pine forests. Many situations and conditions where windfall risk was above and below average were identified. Those results, together with other studies of windfall in the Rocky Mountains, suggest that windfall losses after clearcutting can be reduced if windfall hazards are identified when cutting units are laid out, and care is taken to locate cutting boundary perimeters where windfall hazards are below average.

———— Tackle, David,* and Dahms, Walter G.*

Site indexes for lodgepole pine with corrections for stand density: Methodology. U. S. Forest Serv. Res. Paper RM-29, 18 pp., illus.

Methodology used to develop height-age curves for estimating site index of lodgepole pine is presented. Figures and tables for estimating site index corrected for stand density are also presented. Site indexes adjusted for stand density were developed from data collected in Colorado, Wyoming, Utah, Idaho, Montana, and eastern Washington and Oregon. Instructions for field use were presented in U. S. Forest Service Research Paper RM-24.

Barger, Roland L.

Veneer volume and grade recovery from ponderosa pine in the Southwest. U. S. Forest Serv. Res. Note RM-88, 8 pp., illus.

A study of sample logs from standing trees (26,100 board feet gross scale), sorted into eight quality classes, showed that all classes of lower quality ponderosa pine sawtimber are generally suitable for veneer. The poorest quality class produced more than 20 percent Grade C and better veneer; less than 2 percent of the veneer produced failed to meet minimum commercial standards. A closely integrated sawmill-veneer mill operation, however, would be the most economical, because logs could be sorted for use in the process or product for which they were best suited. Veneer residue and other unsuitable materials could be converted to pulp chips.

Beardsley, Wendell.

Cost implications of camper and campground characteristics in central Colorado. U. S. Forest Serv. Res. Note RM-86, 7 pp., illus.

Large campgrounds (20 or more units) are probably less expensive to operate and maintain—but not necessarily to construct—than smaller ones. Occupancy is determined by physical setting, not size or construction investment. Travel-trailers, tent-trailers, or pickup-campers were used by 58 percent of the families.

Blankenship, James O.,* and Smith, Dixie R.

Breaking seed dormancy in Parry's clover by acid treatment. J. Range Manage. 20: 50.

Immersion in 75-percent sulfuricacid effectively broke seed-coat-imposed dormancy. Length of immersion had no influence on percent germination.

Brown, Gary R.

A device to aid in selecting and counting seeds. J. Range Manage. 20. 52-53, illus.

Seeds are drawn into a stoppered Erlenmeyer flask by vacuum through vinyl tubing and a vacuum tip, made by drawing out a short piece of glass tubing. Diameter of the vacuum tip need be only slightly larger than the seed.

Cable, Dwight R.

Fire effects on semidesert grasses and shrubs. J. Range Manage. 20: 170-176, illus.

Immediate effects of fire on perennial grasses lasted only 1 or 2 years. Burroweed was easily killed, but came back quickly with adequate cool-season moisture. Fire was relatively ineffective against mesquite, fair against cactus.

Chansler, John F.

Biology and life history of Dendroctonus adjunctus (Coleoptera: Scolytidae). Ann. Ent. Soc. Amer. 60: 760-767, illus.

D. adjunctus Blandford (D. convexifrons Hopkins), the roundheaded pine beetle, kills groups of pole-size ponderosa pine, Pinus ponderosa Laws., in New Mexico and Arizona. The range of this forest pest extends from southern Utah and Colorado southward through pine forests to Guatemala. Study of a serious outbreak in southern New Mexico showed the insect to have a 1-year life cycle. The attack period lasts 8-9 weeks, peaking in mid-October. The insect overwinters in the egg and egg-laying adult stages. Development resumes in late March. The larval stage occurs between April and July, pupation in August. Certain physical and biotic factors appear to play an important part in the sudden rise and fall of outbreaks.

Copple, R. F.,* and Pase, C. P.

A vegetative key to some common Arizona range grasses. U. S. Forest Serv. Res. Paper RM-27, 72 pp., illus.

*Private, State or Federal cooperator.

Seventy-seven common Arizona range grasses are included in this key, based on vegetative characters. In addition to the conventional key, a condensed key and groupings of grasses by major characteristics assist in identification. Sketches of ligule and collar areas of each species are supplemented by a detailed description of vegetative characters.

Currie, Pat O.

Seeding Sherman big bluegrass. J. Range Manage. 20: 133-136, illus.

Sherman big bluegrass was successfully established by planting into summer-fallowed land with a double-disc, depth-band drill to control seeding depth at 5/8 inch. Planting during July and August into a moist seedbed gave optimum seedling establishment. Weed competition and erosion on the summer-fallowed land was reduced by leaving the ground in rough-plowed condition until immediately before seeding.

Driscoll, Richard S.

Managing public rangelands. Effective livestock grazing practices and systems for National Forests and National Grasslands. U. S. Dep. Agr. AIB-315, 30 pp., illus.

No single management practice—system of grazing, season of use, rate of stocking, or distribution of livestock—will by itself improve any range area. All these must be integrated into a well-planned management program to use the range most efficiently without jeopardizing other resources.

Evans, Keith, E., and Kerbs, Roger R.

Waterfowl and shorebird use on selected stock ponds in Jackson County: 1966. S. Dak. Bird Notes 19(2): 28-30. (Whole No. 73.)

Twenty-eight species of waterfowl and shorebirds totaling 1,862 individuals, were observed on 13 ponds between April 1 and October 25, 1966. These ponds supported an average of 10 birds per pond for approximately 214 days during 1966. In addition, 30 species of other birds were seen in the area.

Ffolliott, Peter F., and Barger, Roland L.

Occurrence of stem features affecting quality in cutover southwestern ponderosa pine. U. S. Forest Serv. Res. Paper RM-28, 11 pp., illus.

In the southwestern United States, most of the future timber resource is cutover ponderosa pine, and continued development and expansion of the timber industry depends on its quality. Data collected from 3,799 sample trees in northern Arizona on occurrence of visual stem features—sweep, crook, lean, fork, scars, and knots—provide a method for appraising suitability of major timber types for various products and to what extent stem defects reduce the product potential.

Garcia, R. M., and Pase, C. P.

Moisture-retention capacity of litter under two Arizona chaparral communities. U. S. Forest Serv. Res. Note RM-85, 2 pp., illus.

Water-holding capacity of Pringle manzanita litter averaged 5.1 mm., and shrub live oak litter 4.8 mm., under dense, uniform canopies. Pringle manzanita litter held more water per gram of litter than did shrub live oak (2.00 vs. 1.80), but total litter produced was less (11.2 tons per acre vs. 12.1).

Gary, Howard L.

Density variation in a snowpack of northern New Mexico. West. Snow Conf. Proc. 35: 6-10, illus.

Discusses sample variability of horizontal density measurements in snow profiles. The descending order of average sample variation in density was new snow, depth hoar, dry snow, and wet snow.

_____ and Coltharp, George B.

Snow accumulation and disappearance by aspect and vegetation type in the Santa Fe Basin, New Mexico. U. S. Forest Serv. Res. Note RM-93, 11 pp., illus.

Plots on north and south aspects under Douglas-fir, aspen, spruce-fir, and grass cover had maximum snow water equivalents ranging from 7.6 inches on the south-aspect Douglas-fir to 14.5 inches on the south-aspect grass plot. Greatest snow accumulations were observed in the high-elevation spruce-fir and grass types. In this elevation zone there was little difference in accumulation and melt between north and south aspects. Snow melting continued 4 to 5 weeks longer under spruce-fir than under other cover types.

Germain, Charles J., and Wygant, Noel D.

A cylindrical screen cage for rearing bark beetles. U. S. Forest Serv. Res. Note RM-87, 4 pp., illus.

Describes a four-legged cage 12 inches in diameter and 24 inches high, made from 20-mesh wire screen and a tractor funnel. A mason jar fits over funnel outlet to collect the emerging beetles.

Green, Christine R., * and Martin, S. Clark.

An evaluation of precipitation, vegetation, and related factors on the Santa Rita Experimental Range. Meteorol. and Climatol. of Arid Reg. Tech. Rep. 17, 82 pp., illus. Tucson: Inst. Atmos. Physics, Univ. Ariz.

Monthly and annual precipitation data for 45 rain gages over the Santa Rita Experimental Range are presented. A common 26-year period for 22 of the gages is used in statistical analyses. Results are tabulated and presented graphically. Effectiveness of precipitation on vegetation and soil moisture in the area is discussed. Tables and graphs depict the typical effects to be found within the Experimental Range.

Hawksworth, Frank G.

Distribution of ponderosa pine dwarf mistletoe on the South Rim of Grand Canyon, Arizona. U. S. Agr. Res. Serv., Plant Dis. Rep. 51: 1049-1051, illus.

Most infected stands are within 2 miles of the Rim, but at one point the infection extends southward along a broad ridge about 7 miles from the Rim. Reason for this peculiar distribution is unknown; it could be a reflection of climatic factors associated with the Rim, or merely a relatively recent colonization by the dwarf mistletoe.

_____, Wiens, Delbert,* and Graham, Donald P.*

Dwarfmistletoe on Brewer spruce in Oregon. Northwest Sci. 41: 42-44, illus.

Brewer spruce, Picea breweriana S. Wats., is a rare tree restricted to a few areas in northern California and southern Oregon. A thorough reconnaissance is recommended to determine whether a dwarf-mistletoe control program is warranted.

Heede, Burchard H.

Engineering techniques and principles applied to soil erosion control. Panamer. Soil Conserv. Congr., 1st Congr., v 1, sect. 1, pap. 6, 16 pp., illus.

Two basic approaches to erosion control are (1) resisting natural forces, and (2) utilizing them. Examples of (1) are check dams and grassed waterways; of (2), Italian hydraulic reclamation where erosive forces are used to stabilize watersheds. Objective of both is to establish a vegetation cover.

The fusion of discontinuous gullies—a case study. Int. Ass. Hydrol. Bull. 12: 42-50, illus.

In 7 years, only five storms produced runoff in a gully system in the Colorado Front Range of the Rocky Mountains. Storm intensities for 10-minute periods influenced runoff production; antecedent precipitation was of no benefit to forecast gully flow. Neither the upstream progression of the head cut nor the amounts of net erosion caused by the individual flows could be related to storm parameters.

Heidmann, L. J.

Herbicides for preparing ponderosa pine planting sites in the Southwest. U. S. Forest Serv. Res. Note RM-83, 4 pp., illus.

In 1961 and 1962, dalapon, bisester of dalapon, simazine, amitrole, amitrole-T, and ammonium thiocyanate were tested on perennial grasses in Arizona. All of the herbicides except ammonium thiocyanate effectively killed the grass. Dalapon, however, was the cheapest effective herbicide.

Hinds, T. E., and Davidson, R. W.

A new species of Ceratocystis on aspen. Mycologia 59: 1102-1106, illus.

Ceratocystis populina sp. nov., associated with aspen canker in Colorado, forms perithecia with short conical spines, mycelia with racket hyphal cells, and small bean-shaped ascospores.

Hoover, Marvin D.

Forests—where the waterflow starts. U. S. Dep. Agr. Yearb. 1967: 77-79.

Relates the beauty of the mountain forest, especially in winter, to its great value as a water producer for the West. Because striking wind patterns cause uneven deposition of snow, we can manage these forests to increase late-spring runoff and streamflow.

International Union of Forestry Research Organizations.

XIV. IUFRO-Kongress, v. I, Sect. 01-02-11, 504 pp., illus.

The 14th IUFRO Congress was held in Munich, Germany, September 1967. Included in the proceedings of section 11, forest influences and watershed management, are four papers authored or coauthored by Rocky Mountain Station personnel:

Goodell, B. C., Watt, J. P.,* and Zorich, T. M.* Streamflow volumes and hydrographs by fluorescent dyes. pp. 325-348, illus.

Pase, C. P., Ingebo, P. A., Davis, E. A., and McCulloch, C. Y.* Improving water yield and game habitat by chemical control of chaparral. pp. 463-486, illus.

Price, Raymond. Possibilities of increasing streamflow from forest and range watersheds by manipulating the vegetative cover—the Beaver Creek pilot watershed evaluation study. pp. 487-504, illus.

Swanson, Robert H. Improving tree transpiration estimates based on heat pulse velocity measurements. pp. 252-263, illus.

XIV. IUFRO-Kongress, v. V, Sect. 24, 888 pp., illus.

The 14th IUFRO Congress was held in Munich, Germany, September 1967. Included in the proceedings of section 24, forest protection, is one paper authored by Rocky Mountain Station personnel:

Peterson, Glenn W. Dothistroma needle blight of pine in North America. pp. 269-278.

Jameson, Donald A.

Relationship of tree overstory and herbaceous understory vegetation. J. Range Manage. 20: 247-249, illus.

For study of the effect of trees on understory vegetation, a good mathematical equation is helpful. This article presents an equation which fits overstory-understory data better than previously used equations.

Jones, John R.

Aspen site index in the Rocky Mountains. J. Forest. 65: 820-821, illus.

Because plot height growth curves varied considerably for stands with similar heights at index age (80 years), accuracy attainable in site index estimates is limited. Stands older than 40 years gave good estimates; stands younger than 30 were very unreliable.

A modification of the one-foot-square wire seed trap. J. Forest. 65: 490, illus.

Traps with sheet-metal sides are more durable under heavy snow and much easier to empty when wet. Tops are easily put on without deforming the traps. Construction cost is comparable to that of standard traps made of hardware cloth.

Regeneration of mixed conifer clearcuttings on the Apache National Forest, Arizona. U. S. Forest Serv. Res. Note RM-79, 8 pp., illus.

In 1958-59, seven blocks of mixed conifers were clearcut or commercially clearcut. Two were planted and one was spot seeded. In 1965, little post-logging regeneration could be found, natural or artificial. Advance regeneration had largely been destroyed by logging and slash disposal, and some which survived had been seriously browsed. Seed fall, seedbeds, weather, animals, and other possible factors are discussed and the management implications pointed out.

Knipe, O. D.

Influence of temperature on the germination of some range grasses. J. Range Manage. 20: 298-299.

Boer lovegrass, galleta, and blue grama germinate relatively well within a temperature range of 60° to 100° F., but the range required for good germination of alkali sacaton and Lehmann lovegrass is limited to 80° to 90° and 60° to 70° F, respectively.

Larson, M. M.

Effect of temperature on initial development of ponderosa pine seedlings from three sources. Forest. Sci. 13: 286-294.

Root growth responded more to soil temperature, while top growth responded more to air temperature. Both were significantly influenced by the interaction of air and soil temperature. Seedlings did not require an alternating day-night temperature. The source of seed had a pronounced effect on final seedling size.

Leaf, Charles F.

Areal extent of snow cover in relation to streamflow in central Colorado. Int. Hydrol. Symp. Proc. 1967(v. 1): 157-164, illus.

Aerial photography indicates that snow depletion rates are highly correlated with seasonally generated runoff volumes. Patterns of snow depletion and generated runoff have been consistent from year to year, even though the amount of snow and weather conditions which produced runoff were not the same.

Lightle, Paul C., Andrews, Stuart R., and Mouser, William E.*

Recleaning the dwarfmistletoe control area on the Mescalero Apache Reservation, New Mexico. J. Forest. 65: 816-817, illus.

Development of latent and missed infections necessitated recleaning a large-scale test area 6 to 9 years after the original dwarf mistletoe control. Infection was reduced to less than 1 percent—the same level achieved originally. Recleaning cost $7.09 per acre, compared to $5.26 for the original operation.

McCambridge, William F.

Nature of induced attacks by the Black Hills beetle, Dendroctonus ponderosae (Coleoptera: Scolytidae). Ann. Ent. Soc. Amer. 60: 920-928, illus.

Black Hills beetle attractants, made by attaching infested bolts to green trees or forcing attacks on such trees under screen cages, provided a means to study how the beetle attacks trees and stands. Attractant trees were always infested first; first attacks occurred below 8 feet, and generally below 4 feet. Initial attacks on adjacent trees, which occurred during the mass attack, appeared slightly higher on the trees but not higher than 10 feet. Subsequent attacks occurred below and above the initial attacks, with the mean height increasing with time. Trees became infested at progressively greater distances from the attractant center. Infested trees were significantly larger than green trees within the radius of infestation. The greatest number of attacks was recorded at the end of the 4 p.m. to 6 a.m. period.

McKnight, M. E.

Distribution of hibernating larvae of the western budworm on Douglas-fir trees. Ent. Soc. Amer. Bull. (N. Y. Program Issue) 13(3): 195.

More larvae hibernated on the branches than on the bole. The largest percentage of the total hibernated on the branches of the lower one-third of the crown. (Abstract of paper presented at annual meeting of the Entomological Society of America held in New York City, November 1967).

Martin, S. Clark, Barnes, Kenneth K.,* and Bashford, Leonard.*

A step toward automatic weighing of range cattle. J. Range Manag. 20: 91-94, illus.

A battery-operated electronic scale recorded range cattle weights accurately on oscillograph charts without disturbing the animals. With refinement, the system could operate automatically.

Massey, Calvin L.

Nematodes associated with tree-infesting insects: Paurodontidae new family and Misticiinae new subfamily with a description of one new genus and four new species. Can. J. Zool. 45: 779-786, illus.

Contents indicated by title.

Megahan, W. F.,* Meiman, J. R.,* and Goodell, B. C.

Net, allwave radiation as an index of natural snowmelt and snowmelt accelerated with albedo-reducing materials. Int. Hydrol. Symp. Proc. 1967(v. 1): 149-156, illus.

Measured radiant energy was related to measured snowmelt under extreme ranges of snow albedo with correlation coefficient of 0.95. Snowmelt was accelerated an average of 2.8 times with the use of albedo-reducing materials for a 1-day period.

Morris, Meredith J.

An abstract bibliography of statistical methods in grassland research. U. S. Dep. Agr. Misc. Pub. 1030, 222 pp.

Prepared for scientists concerned with problems of defining and measuring biotic parameters and of sampling populations in grassland communities, the publication is a collection of references on the applications of statistics to these problems. Abstracts are included with most of the references. It should be a useful tool in designing new studies of grassland problems.

Mueller, Lincoln A., and Kovner, J. L.

Lumber production from selected Black Hills ponderosa pine. U. S. Forest Serv. Res. Pap. RM-31, 20 pp., illus.

A study of 1,468 logs from 498 trees provided a basis for determining the adequacy of the timber-estimating procedure used on the Black Hills National Forest, and for determining the volume of lumber by grade that can be expected from the range of log diameters and grades available.

Myers, Clifford A.

Growing stock levels in even-aged ponderosa pine. U. S. Forest Serv. Res. Pap. RM-33, 8 pp., illus.

Growth of ponderosa pine is under study in a coordinated investigation by the four western experiment stations of the U. S. Forest Service. Response of combinations of tree size, site index, and stand density will be determined. Results will be used to make forecasts of yield for possible alternatives of management.

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Stocking control in the ponderosa pine region. In Too many trees? West. Forest. and Conserv. Ass., West. Reforest. Coord. Comm. Proc. 1966: 40-42.

Young ponderosa pines need some competition to produce suitably small knots and a pleasing landscape. In our efforts to save money on regeneration costs and precommercial thinning, we may end up with a product that has no value. Considering probable future product requirements, recreation aspects, and growth habit, very few intentionally regenerated areas have too many trees.

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Yield tables for managed stands of lodgepole pine in Colorado and Wyoming. U. S. Forest Serv. Res. Paper RM-26, 20 pp.

Presents working tools useful in the compilation of yield tables for managed, even-aged stands. Stand age at initial thinning, stocking goals, and other management controls may be varied as desired. The yield table that best describes the objectives of management becomes the standard for the Forest.

Pase, C. P.

Helicopter-applied herbicides control shrub live oak and birchleaf mountainmahogany. U. S. Forest Serv. Res. Note RM-84, 4 pp., illus.

Four annual helicopter applications of 2, 4, 5-T to fire sprouts of chaparral held shrub live oak and birchleaf mountainmahogany cover to less than 5 percent, while unsprayed sprouts increased to 21 percent. No difference was found between emulsifiable and invert forms of 2, 4, 5-T, and 1:1 mixtures of oil soluble 2, 4, 5-T and 2, 4-D. PBA and TBA were substantially less effective in retarding shrub growth.

Pearson, Henry A.

Cattle diet digestibilities determined from components. J. Range Manage. 20: 405-406, illus.

In vitro digestibilities of diet mixtures and of individual forage species, adjusted for their relative proportions in the range cattle diet, were interchangeable.

Effect of delays in inoculum collection on artificial rumen digestibilities. J. Range Manage. 20: 332-333, illus.

Range forage samples were digested (in vitro) with rumen inoculum collected after delays of 2, 6, 10, and 14 weeks after the forage collection. Inoculum collected after the 6-week delay gave equivalent forage digestibility values as the 2-week delay; 10-week inoculum delay resulted in digestion values statistically related to but lower than the 2-week delay values. Inoculum collected after a 14-week delay could not be used to estimate range forage digestibility.

Phenology of Arizona fescue and mountain muhly in the northern Arizona ponderosa pine type. U. S. Forest Serv. Res. Note RM-89, 4 pp., illus.

In northern Arizona, height growth of Arizona fescue, a cool-season grass, increased greatest during May while mountain muhly, a warm-season grass, increased greatest during July and August. Flower stalks developed earlier for fescue than muhly.

Rumen microorganisms in buffalo from southern Utah. Appl. Microbiol. 15: 1450-1451.

Rumen microbial populations from buffalo (Bison bison bison Linn.) in southern Utah were identified on the basis of their morphology and staining characteristics. The rumen bacteria and ciliate protozoa were similar in number and kind to those found in domestic livestock.

Peterson, Glenn W.

Botryodiplodia disease of Russian-olive. Phytopathology 57: 825-826.

Abstract of paper presented at American Phytopathological Society meeting in Maryland, August 1967.

Control of Cylindrosporium leaf spot disease of Rhus trilobata and Shepherdia argentea seedlings. U. S. Agr. Res. Serv. Plant Dis. Rep. 51: 700-701.

Captan and Maneb sprayed weekly from June 15 to August 31 provided effective control.

Dothistroma needle blight of Austrian and ponderosa pines: epidemiology and control. Phytopathology 57: 437-441, illus.

Stroma development began in the fall of year of infection. Conidia did not develop in stromata until early spring. Conidia germinated over a wide temperature range (12-28° C). Pine needles were penetrated through stomata. First infection occurred early in the growing season. Symptoms were evident 4 months after infection. Current-year needles were initially resistant to D. pini, but became susceptible in midsummer. Good control was obtained with Bordeaux mixture and other copper fungicides.

Potter, Loren D.,* and Krenetsky, John C.*

Plant succession with released grazing on New Mexico range lands. J. Range Manage. 20: 145-151, illus.

After 25 years of protection from grazing, grassland plots tripled in percent of ground cover of grasses. Grazed desert grasslands showed continued increases of mesquite. Protection resulted in remarkable increases in grass cover in ponderosa pine and aspen types.

Raski, D. J.,* and Riffle, J. W.

Two new species and further notes on Criconemoides Taylor, 1936 (Criconematidae: Nematoda). Helmin. Soc. Wash. Proc. 34: 212-219.

Criconemoides dividus and C. humilis are described as new species; additional collections are reported for C. informis, C. lamellatus, C. annulatus, C. macrodorus, and C. xenoplax; additional descriptions are made from type specimens of C. demani and C. sphagni for which lectotypes and paralectotypes are designated; C. montserrati, C. beljaevae, and C. tennuiannulatus are transferred to species inquirendae.

Read, Ralph A.

Hybrid poplar performance at 10 years in the Nebraska sandhills. U. S. Forest Serv. Res. Note RM-91, 8 pp., illus.

Hybrids containing Populus deltoides and P. nigra cv. Caudina appear to offer the best chance of performing satisfactorily in the Nebraska sandhills region.

---------- and Bagley, W. T.*

Effect of gibberellic acid spray on seedlings of eastern redcedar, bur oak, and red oak. U. S. Forest Serv. Res. Note RM-82, 2 pp., illus.

A 30 p.p.m. solution of gibberellic acid sprayed two or three times a week produced striking increases in height growth on the oaks, but not on redcedar.

---------- and Bagley, Walter T.*

Response of tree seedlings to extended photoperiods. U. S. Forest Serv. Res. Paper RM-30, 16 pp., illus.

Seedlings of Juniperus virginiana, Pinus ponderosa, P. nigra, PopulusXacuminata, Quercus macrocarpa, Q. alba, and Q. rubra were grown under 14- and 24-hour photoperiods, and 14-hour photoperiods with one and two light interruptions in the dark period. Most experiments covered two or three growing periods, in the greenhouse in winter and outdoors in summer, with very short rest periods. Seedlings were usually tallest and heaviest under continuous light, intermediate under the interrupted dark. Long photoperiod stimulated top growth more than root growth, but did not affect field survival. Several phenological changes were observed.

Reynolds, Hudson, G.

Arthur W. Sampson—Pioneer range scientist. Teaching and research at the University; chronological bibliography. J. Range Manage. 20: 349-352.

Portions of a brief biography of Sampson, internationally known range scientist, plant ecologist, and

professor of forestry, born in 1884, who died of pneumonia, February 7, 1967.

Reynolds, Hudson G.

Chemical constituents and deer use of some crown sprouts in Arizona chaparral. J. Forest. 65: 905-908, illus.

Analysis of deer use in relation to chemical composition of mountainmahogany (Cercocarpus betuloides Nutt.), shrub live oak (Quercus turbinella Greene), and Wright silktassel (Garrya wrightii Torr.) indicated that sprout selection was (1) greatest from May through July, (2) in favor of mountainmahogany, and (3) associated with high moisture and crude protein content, low crude fiber, and a comparatively wide calcium-phosphorus ratio.

Rice, R. W.,* and Johnson, W. M.

Intake and digestion estimates of grazed forage. Amer. Soc. Anim. Sci., West. Sect. Proc. 18: 267-272. (Abstract in J. Anim. Sci. 26: 938.)

Seventy-nine percent of the variation in weight gain of sheep could be explained by grazing intensity, forage lignin, fecal fiber, fecal chromogen, and average weight of sheep.

Riffle, Jerry W.

Effect of an Aphelenchoides sp. on the growth of a mycorrhizal and a pseudomycorrhizal fungus. Phytopathology 57: 541-544, illus. (Abstract in Nematologica 13: 151.)

An undescribed Aphelenchoides species greatly reduced the diameter growth of aerial and substrate mycelium of Suillus granulatus and Mycelium radicis atrovirens in two laboratory experiments. The nematode reproduced readily on both fungi and destroyed 87 percent of the S. granulatus cultures; M. radicis atrovirens cultures, however, were not destroyed. Nematodes were not able to maintain themselves in cultures that contained an agar medium but lacked the fungi.

_____ and Kuntz, James E.

Pathogenicity and host range of Meloidogyne ovalis. Phytopathology 57: 104-107, illus.

M. ovalis parasitized rootlets of sugar maple, American elm, and white ash in the field. Numerous galls and typical giant cells were formed on the infected rootlets. In the greenhouse, this root knot nematode infected 12 of 19 woody plant species, but reproduced only on four maple species, two birch species, and American elm. Of 29 herbaceous plant species tested, the nematode infected geranium, onion, tomato, and carrot, but did not reproduce on them.

Ronco, Frank.

Lessons from artificial regeneration studies in a cutover beetle-killed spruce stand in western Colorado. U. S. Forest Serv. Res. Note RM-90, 8 pp., illus.

Eleven specific lessons were learned about factors that affect seed germination, seedling establishment, and plantation success with Engelmann spruce and lodgepole pine.

Schmid, J. M.

Asilid predation on the Black Hills beetle, Dendroctonus ponderosae. Ent. Soc. Amer. Bull (N. Y. Program Issue) 13: 195.

The adult asilid, Laphria gilva, preys on Black Hills beetles during their emergence period. The asilid orients itself on a beetle-infested tree, and captures the beetle in flight as the beetle flies from the tree. The significance of the asilid predation was examined. (Abstract of paper presented at annual meeting of the Entomological Society of America held in New York City, November 1967).

Smith, Dixie R.

Gross energy value of aboveground parts of alpine plants. J. Range Manage. 20: 179-180, illus.

Gross energy of aboveground parts of alpine plants averaged 4.16 kcal/g during the summer months. This is below the average values reported by other authors.

_____, Fisser, Herbert G.,* Jefferies, Ned,* and Stratton, Paul O.*

Rotation grazing on Wyoming's Big Horn Mountains. Wyo. Agr. Exp. Sta. J. 13, 26 pp., illus.

On grassland range, at 8,000 feet altitude, two ranges were stocked at a moderate rate. One was grazed in a three-pasture deferred-rotation system; the other seasonlong. A third range was stocked at 1-1/2 times that rate, and grazed in the deferred-rotation system. Steers were grazed from about June 20 to September 20 each year, 1959 through 1964. Average utilization of Idaho fesuce, the key management species, was 20 percent for moderate-rotation, 30 percent for moderate-season-long, and 43 percent for heavy-rotation. Weight gain by steers averaged 2.2, 2.1, and 1.8 pounds per day, respectively. Range deteriorated on the area grazed by the heavy-rotation system, but not on the other two ranges.

Smith, Dwight R.

Effects of cattle grazing on a ponderosa pine-bunchgrass range in Colorado. U. S. Dep. Agr. Tech. Bull. 1371, 60 pp., illus.

Reports results of grazing studies on the Manitou Experimental Forest from 1940-59; replaces USDA Circular 929, issued December 1953.

Springfield, H. W.

Percentage of filled fourwing saltbush seeds. U. S. Forest Serv. Res. Note RM-81, 4 pp., illus.

Only slightly more than half of 16,000 seeds from 117 collections throughout Arizona and New Mexico contained embryos. Seed size varied considerably among collections; percent fill usually was highest in the larger seeds of any one collection. Cutting tests are recommended so that seeding rates can be adjusted to compensate for empty seeds.

_____ and Bell, Donald G.

Depth to seed fourwing saltbush. J. Range Manage. 20: 180-182, illus.

De-winged seeds of fourwing saltbush were sown at ½-, 1-, 1-½-, and 2-inch depths in two soils. Total seedling emergence at the end of 30 days was greater, and the rate of emergence higher, from the shallower depths of seeding. Seedlings emerged about the same in sandy loam and clay loam soils. Seeding depths of ½ to 1 inch are suggested for de-winged seeds.

_____ and Reid, Elbert H.

Crested wheatgrass for spring grazing in northern New Mexico. J. Range Manage. 20: 406-408, illus.

Crested wheatgrass provides green forage during May and June when native grasses are critically

short. Over a 7-year period, yearling cattle gained 1.98 pounds per acre per day on seeded range; 1.50 pounds on adjacent native range. Lamb crops were 4 to 7 percent larger.

Staley, John M., and Hawksworth, Frank G.

Bifusella crepiformis on Engelmann spruce. U. S. Agr. Res. Serv., Plant Dis. Rep. 51: 791-792.

The fungus has recently been reported on Engelmann spruce in Canada. This is the first record of its occurrence in Montana.

Stelzer, Milton J.

Control of a tent caterpillar, Malacosoma fragile incurva, with an aerial application of a nuclear-polyhedrosis virus and Bacillus thuringiensis. J. Econ. Ent. 60: 38-41, illus.

The application of a nuclear-polyhedrosis virus and B. thuringiensis Berliner by helicopter resulted in a high rate of infection of colonies of the tent caterpiller, M. fragile incurva Henry Edwards. The incidence of diseased colonies, i.e., colonies containing at least one virus-killed larva, increased with increases in spray deposit and time (days) after spraying. Populations were 95 percent lower in the sprayed area than in the unsprayed area the year following treatment.

Sturges, David L.

Water quality as affected by a Wyoming mountain bog. Water Resource Res. 3: 1085-1089, illus.

Samples were taken from effluent stream, fissure, and peat locations within the bog, and ground water. Dissolved mineral content of all waters was very low, and chemical quality was excellent. All water contained coliform organisms, probably of nonfecal origin.

Swanson, Robert H.

A low-cost instrument to measure temperature or resistance accurately. U. S. Forest Serv. Res. Note RM-80, 4 pp., illus.

A linear, 10-turn potentiometer, with 1,000-digit readout dial, forms the ratio arms of a Wheatstone bridge for measuring resistance within 1 percent over a limited range.

Tiedemann, Arthur R., and Pond, Floyd W.

Viability of grass seed after long periods of uncontrolled storage. J. Range Manage. 20: 261-262.

In 1961, germination tests were made on seed of 12 southwestern grass species collected between 1933 and 1939. Some seeds of vine-mesquite, silver beardgrass, curlymesquite, and Arizona cottontop remained viable, even though stored with no control of humidity or temperature.

Van Deusen, James L.

Conversion of tree heights in logs to heights in feet: Black Hills ponderosa pine. U. S. Forest Serv. Res. Note RM-94, 2 pp.

Gives conversion factors for converting heights in 16-foot logs to heights in feet so trees can be sold by the cord as roundwood.

Wilson, Alvin K.,* and Spencer, John S., Jr.*

Timber resources and industries in the Rocky Mountain States. U. S. Forest Serv. Resource Bull. INT-7, 63 pp., illus.

Statistics from many sources have been compiled to present the most complete set of data on timber inventory, cut, and timber products output that has ever been prepared for the Rocky Mountain States as a whole.

Worley, David P.

A forest inventory approach to multiple-use analysis. Soc. Amer. Forest. Proc. 1966: 138-142, illus.

Inventory data can be presented so that estimates can be used in two ways: as a basis for selecting among alternative management options, or as a basis for multiple-use coordination. The resulting information would be useful to both small landowners and large organizations.

Wright, Jonathan, W.,* Pauley, Scott S.,* Polk, R. Brooks,* Jokela, Jalmer J.,* and Read, Ralph A.

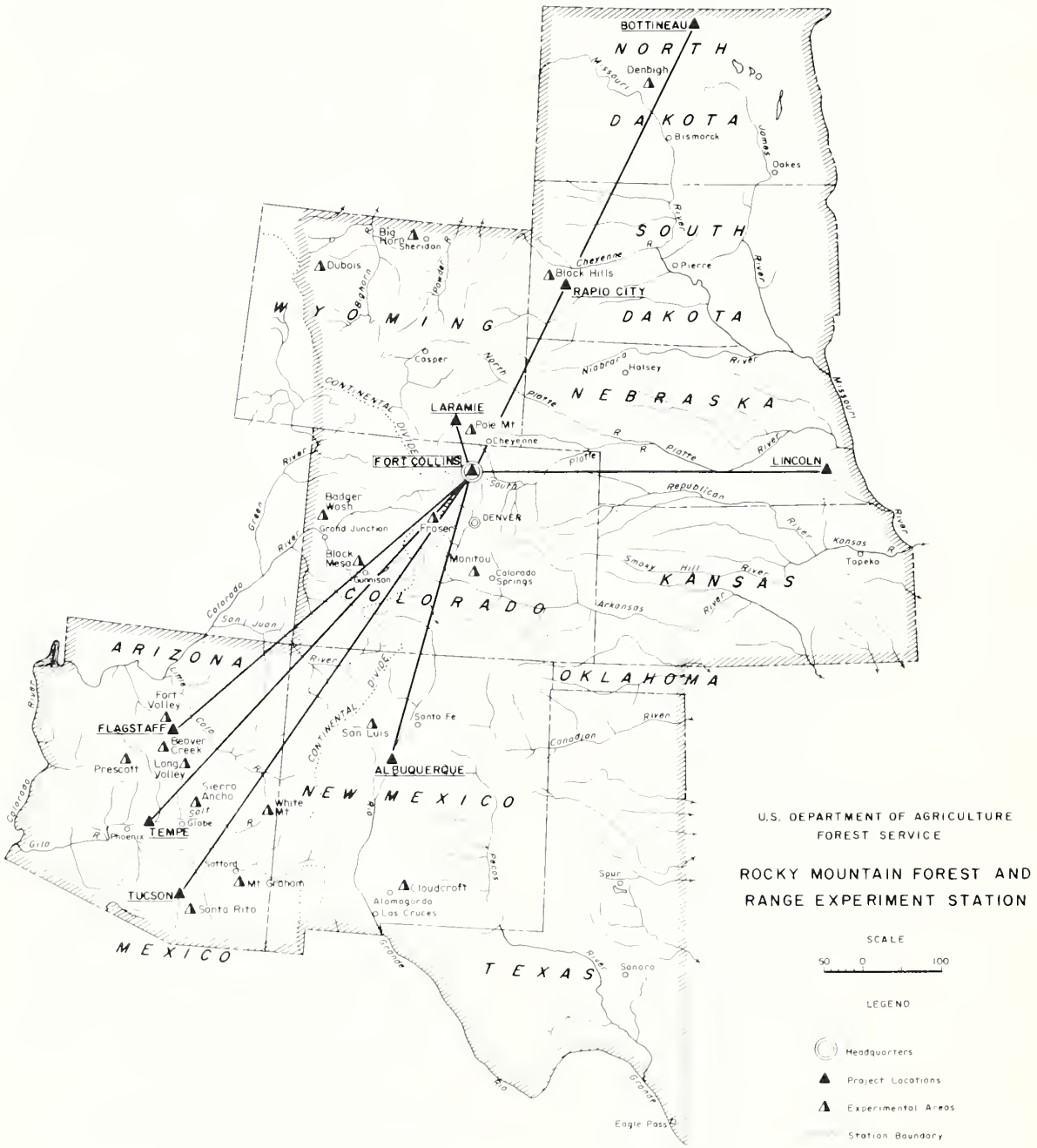
Performance of Scotch pine varieties in the north central region. Silvae Genetica 15(4): 101-110, illus.

Presents data on performance of seed sources for use in central United States where Scotch pine is being grown on a large scale, and provides material for studies on the mechanisms of growth. Is part of the NC-51 project on "Forest Tree Improvement through Selection and Breeding," and was supported in part by regional research funds from the USDA.

Yerkes, Vern P.

Effect of seasonal stem moisture variation and log storage on weight of Black Hills ponderosa pine. U. S. Forest Serv. Res. Note RM-96, 8 pp., illus.

The moisture content of ponderosa pine trees in the Black Hills fluctuated enough from season to season to account for a significant portion of the variability that might be experienced in weight scaling. A difference in moisture content of trees on different growing sites was also noted. Weight loss from logs left in woods storage for up to 108 days was not great and could be largely ignored in weight scaling. Lumber degrade during storage would probably be a more serious problem, and normally would be the main concern in log storage.


BOTTINEAU
NORTH
DAKOTA
Denbigh
Bismarck
James
Oakes
SOUTH
DAKOTA
Pierre
RAPID CITY
Black Hills
Big Horn
Sheridan
Dubois
WYOMING
Casper
Niobrara
Halsey
NEBRASKA
LARAMIE
Pole Mt
Cheyenne
FORT COLLINS
LINCOLN
Republican
Badger Wash
Grand Junction
DENVER
Fraser
Block Mesa
Gunnison
Monitou
Colorado Springs
Smoky Hill
KANSAS
Topeka
COLORADO
Arkansas
ARIZONA
OKLAHOMA
Fort Valley
FLAGSTAFF
Beaver Creek
Prescott
Long Valley
Sierra Ancho
Salt
Globe
White Mt
TEMPE
Phoenix
Gila
Santa Fe
San Luis
Canadian
ALBUQUERQUE
NEW MEXICO
Pecos
Rotford
Mt Graham
TUCSON
Santa Rita
Cloudcroft
Alamogordo
Las Cruces
Spur
Sonora
MEXICO
TEXAS
Eagle Pass
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
ROCKY MOUNTAIN FOREST AND
RANGE EXPERIMENT STATION
SCALE
50 0 100
LEGEND
Headquarters
Project Locations
Experimental Areas
Station Boundary

COMMON AND BOTANICAL NAMES OF ANIMALS AND PLANTS MENTIONED

ANIMALS

Birds

Grouse, sharp-tailed	*Pedioecetes phasianellus jamesi* Lincoln
Praire chicken, greater	*Tympanuchus cupido pinnatus* (Brewster)
Turkey, Merriam's	*Meleagris gallapavo merriami* Nelson

Mammals

Deer	*Odocoileus* spp.
Deer, mule	*Odocoileus hemionus hemionus* (Rafinesque)
Deer, white-tailed (Arizona)	*Odocoileus virginianus couesi* (Coues & Yarrow)
Deer, white-tailed (South Dakota)	*Odocoileus virginianus dacotensis* Goldman & Kellogg
Elk	*Cervus canadensis canadensis* (Erxleben) Reynolds
Mouse, deer	*Peromyscus maniculatus* (Wagner)
Pocket gopher, northern	*Thomomys talpoides* (Richardson)
Vole, montane	*Microtus montanus* (Peale)

PLANTS

Forbs

Agoseris	*Agoseris* spp.
Dandelion	*Taraxacum* spp.
Dandelion, common	*Taraxacum officinale* Wiggars
Fleabane, aspen	*Erigeron macranthus* Nutt.
Geranium, Fremont	*Geranium fremontii* Torr.
Gilia, slenderleaf	*Collomia linearis* Nutt.
Hoarhound	*Marrubium vulgare* L.
Lettuce, prickly	*Lactuca serriola* L.
Lupine	*Lupinus* spp.
Peavine, aspen	*Lathyrus leucanthus* Rydb.

Grasses and Grasslike Plants

Beargrass, silver	*Andropogon saccharoides* Swartz.
Bluegrass, Kentucky	*Poa pratensis* L.
Brome, fringed	*Bromus ciliatus* L.
Bullgrass	*Muhlenbergia emersleyi* Vasey
Cottontop, Arizona	*Trichachne californica* (Benth.) Chase
Curlymesquite	*Hilaria belangeri* (Steud.) Nash
Fescue, Idaho	*Festuca idahoensis* Elmer
Fescue, Thurber	*Festuca thurberi* Vasey
Grama, hairy	*Bouteloua hirsuta* Lag.
Grama, sideoats	*Bouteloua curtipendula* (Michx.) Torr.
Lovegrass, Lehmann	*Eragrostis lehmanniana* Nees
Lovegrass, plains	*Eragrostis intermedia* Hitchc.
Lovegrass, weeping	*Eragrostis curvula* (Schrad.) Nees
Sacaton, alkali	*Sporobolus airoides* (Torr.) Torr.
Sprangletop, green	*Leptochloa dubia* (H.B.K.) Nees
Sudan grass	*Sorghum sudanense* (Piper) Stapf.
Threeawn, purple	*Aristida purpurea* Nutt.
Vine-mesquite	*Panicum obtusum* H.B.K.
Wheatgrass, crested	*Agropyron cristatum* (L.) Gaertn.
Wolftail	*Lycurus phleoides* H.B.K.

Shrubs and Trees

Ash, green	*Fraxinus pennsylvanica* Marsh.
Aspen, quaking	*Populus tremuloides* Michx.
Boxelder	*Acer negundo* L.
Buffaloberry, silver	*Shepherdia argentea* (Pursh) Nutt.
Calliandra	*Calliandra* spp.
Cercocarpus	*Cercocarpus* spp.
Chokecherry	*Prunus virginiana* L.
Cottonwood	*Populus deltoides* Bartr.
Cypress, Arizona	*Cupressus arizonica* Greene
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Elm, American	*Ulmus americana* L.
Elm, Siberian	*Ulmus pumila* L.
Fir	*Abies* spp.
Fir, white	*Abies concolor* (Gord. & Glend.) Lindl.
Hawthorn	*Crataegus* spp.
Juniper	*Juniperus* spp.
Juniper, alligator	*Juniperus deppeana* Steud.
Juniper, Rocky Mountain	*Juniperus scopulorum* Sarg.
Juniper, Utah	*Juniperus osteosperma* (Torr.) Little
Manzanita	*Arctostaphylos* spp.
Mimosa	*Mimosa* spp.
Mountainmahogany, true	*Cercocarpus montanus* Raf.
Oak	*Quercus* spp.
Oak, Gambel	*Quercus gambelii* Nutt.
Oak, shrub live	*Quercus turbinella* Greene
Paloverde	*Cercidium floridum* Benth.
Pea shrub, Siberian	*Caragana arborescens* Lam.
Pine, Austrian	*Pinus nigra* Arnold
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, pinyon	*Pinus edulis* Engelm.
Pine, ponderosa	*Pinus ponderosa* Lawson
Pine, Scots	*Pinus sylvestris* L.
Plum, American	*Prunus americana* Marsh.
Rabbitbrush, Parry	*Chrysothamnus parryi* (A. Gray) Greene
Redcedar, eastern	*Juniperus virginiana* L.
Rose	*Rosa* spp.
Russian-olive	*Elaeagnus angustifolia* L.
Sagebrush, big	*Artemisia tridentata* Nutt.
Saltbush, fourwing	*Atriplex canescens* (Pursh) Nutt.
Silktassel	*Garrya* spp.
Silverberry	*Elaeagnus commutata* Bernh.
Snowberry, western	*Symphoricarpos occidentalis* Hook.
Spruce	*Picea* spp.
Spruce, Engelmann	*Picea engelmannii* Parry